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Technical Support Document for Proposed Regulations Under Section 304(d)(4) of the Clean Water Act, as Amended

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FOR
PROPOSED REGULATIONS UNDER SECTION 304(d)(4)
OF THE CLEAN WATER ACT, AS AMENDED

Facility Requirements Division
Office of Water
U.S. Environmental Protection Agency
Washington, D.C. 20460

August, 1984

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This document has been prepared to provide technical support for the regulatory amendments to the secondary treatment regulation to implement Sections 301 and 304 of the Clean Water Act.

The information presented supports final regulations that would establish criteria for facilities eligible for treatment equivalent to secondary treatment, a minimum level effluent quality attainanable by such facilities.

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ABSTRACT

This document has been prepared to provide technical support for the regulatory amendments to the secondary treatment regulation to implement Sections 301 and 304 of the Clean Water Act (the Federal Water Pollution Control Act of 1972, 33 USC 1251 et seq., as amended by the Clean Water Act of 1977, P.L. 95-217, and the Municipal Wastewater Treatment Construction Grant Amendments of 1981, P.L. 97-117, referred to hereafter as CWA or the Act). This document specifically addresses Section 304(d)(4) of the Act, 33 U.S.C. 1314(d)(4), which deemed certain biological treatment facilities as equivalent to secondary treatment.

The information presented supports final regulations that would establish criteria for facilities eligible for treatment equivalent to secondary treatment, a minimum level of effluent quality attainable by such facilities, and criteria for adjusting the permit effluent limitations for eligible facilities. This report presents and discusses data gathering efforts, review of biological treatment technologies, classification of certain facilities using such treatment processes, the performance capabilities of biological treatment processes, and other considerations used by the Agency in development of regulatory options and effluent requirements.

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SECTION I

EXECUTIVE SUMMARY

A. SUMMARY AND CONCLUSION

This document presents the technical data to support the minimum levels of effluent quality attainable by municipal wastewater treatment facilities deemed equivalent to secondary treatment under provisions of Section 304(d)(4) of the Clean Water Act (the Federal Water Pollution Control Act of 1972, 33 USC 1251 et seq., as amended by the Clean Water Act of 1977, P.L. 95-217, and the Municipal Wastewater Treatment Construction Grant Amendments of 1981, P.L. 97-117, referred to hereafter as CWA or the Act). It also describes the basis for the Agency's classification of certain facilities as eligible for treatment equivalent to secondary treatment.

The focus in developing these regulatory amendments was a data collection effort aimed at characterizing the performance levels and performance variability of various existing technologies used to provide biological treatment of municipal wastewater. Such treatment is characterized by a diversity of treatment process types, design, plant size and age, influent characteristics and effluent characteristics. Classes of facilities based on process type and age were defined for the purpose of the technical evaluation. Each class was characterized in terms of a typical performance level consistently achieved. The technical evaluation assessed the ability of a class to reliably achieve current secondary treatment requirements in terms of the defined performance level. Those classes that provide treatment equivalent to secondary treatment, i.e, could not consistently achieve current requirements (see legislative history, Appendix B), formed the basis for establishing eligibilities and minimum levels of effluent quality.

Sections II, III, IV and V of this document describe the technical data and other analyses used to develop the class of facilities eligible for treatment equivalent to secondary treatment. Long-term data analyses used to support the proposed minimum level of effluent quality attainable by such facilities is described in Sections IV and VI of this document.

B. FINAL REGULATORY AMENDMENTS

1. Eligibilities

The final rule uses the following criteria (§ 133.101(g)) to define a category of existing facilities that provide treatment equivalent to secondary treatment: (a) the facilities cannot consistently achieve secondary treatment as currently defined, (b) the facilities employ either a trickling filter or a waste stabilization pond as the principal biological treatment process, and (c) the facilities provide for significant biological treatment of raw wastewater (at least 65 percent removal of BOD_5).

a. Inability of Facility to Consistently Achieve Secondary Treatment. Under the final provisions (§ 133.101(g)(1)), only those trickling filter and waste stabilization pond facilities that cannot consistently meet secondary treatment requirements are eligible for a modification of the secondary treatment requirements. This provision is based on the legislative history for Section 304(d)(4) of the Act which indicates that "equivalent" facilities cannot consistently achieve current secondary treatment requirements (see Section II of this document).

The effluent quality achievable by a facility is defined in terms of the 30-day average BOD_5 and SS values achieved 95 percent of the time, based on at least two years of data, excluding upsets, bypasses, instances of operator error and other unusual conditions.

b. Use of Trickling Filter or Waste Stabilization Pond as Principal Process. An eligible facility must use a trickling filter or waste stabilization pond as the principal process for providing significant biological treatment (§ 133.101(g)(2)). The statute specifically lists trickling filters and waste stabilization ponds as examples of biological treatment processes that an eligible facility may use to provide treatment equivalent to secondary treatment.

The term "principal process" is used to suggest the major biological treatment components that are directly in the treatment process train, rather than ancillary components. By focusing on "principal" processes, the final regulation would not exclude those facilities that incorporate minor components for improved treatment, e.g., the addition of covers, chemical feeds, solids contact processes for trickling filter, or the addition of sand filters or aeration for waste stabilization ponds, provided that the trickling filter or waste stabilization pond unit is the principal process that results in significant removal of BOD_5.

c. Significant Biological Treatment. Equivalent treatment works must provide significant biological treatment of wastewater. These provisions are based on the legislative history that Congress intended for certain facilities to be deemed the equivalent of secondary treatment if they achieve significant pollutant reductions, even though they cannot consistently meet EPA's existing secondary treatment requirements.

The Agency has determined that when a trickling filter or waste stabilization pond process is used as a biological treatment process the overall facility of which they are a part can be expected to remove between 60 and 90 percent of BOD_5 (see Section III of this document). It is also noted that the legislative history for the 1972 Clean Water Act described primary treatment as removing from 30 to 50 percent of organic matter, i.e., BOD_5, while secondary treatment was described as removing from 50 to 90 percent removal of BOD_5 [S. Rep. 92-414, 92d Cong., 2d Sess. 6 (1972)]. In §§ 133.101(k) and 133.101(g)(3), the Agency requires that a treatment facility deemed equivalent to secondary treatment provide an overall facility BOD_5 removal of at least 65 percent on a 30-day average basis.

This provision ensures that the facilities applying for permit adjustments provide a level of treatment significantly beyond that achieved through primary treatment, i.e., physical separation and removal of grit, coarse sands, settlable, and floatable materials. Thus, the use of a trickling filter or waste stabilization pond as a preliminary treatment process, e.g., roughing filters or equalization basins, would not meet the definition of significant biological treatment (§ 133.101(k)).

2. Minimum Level of Effluent Quality Attainable

The minimum level of effluent quality generally attainable is summarized below

Parameter	30-Day Average	7-Day Average	Percent Removal
BOD_5 (mg/L)	45	65	65
TSS (mg/L) *	45	65	65

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* Except where alternative TSS requirements have been established for waste stabilization ponds under existing secondary treatment provisions (§ 133.103(c)). The existing 2 MGD flow limitation on the eligibility of waste stabilization ponds for this existing provision is removed.

3. Case-by Case Effluent Limitations

Specific numeric effluent limitations for an eligible facility are established on a case-by-case basis by the NPDES permitting authority (§ 133.105(e)); in no case, however, could the minimum levels of effluent quality established at the national (or State) level be exceeded. In implementing a case-by-case approach. Permit adjustments are based upon the performance capabilities of a treatment works. These requirements reflect the direction of Congress that the Administrator issue regulations that consider the design of the facilities. Since the legislative history does not indicate any intent on the part of Congress to sanction poor operation and maintenance, or the abandonment of treatment processes [cf. S. 1274, 97th Cong., 1st Sess. § 16 (1981), 127 Cong. Rec. S5527 (May 21, 1981); H.R. Rep. No. 97-30, 97th Cong., 1st Sess. 34-35 (1981)], effluent limitations must be based on proper operation and maintenance of facilities within their design capacity.

Permit writer guidance on issues to consider in setting case-by-case effluent limitations is contained in Section VIII of this document. In each case a permit must reflect effluent limitations that will assure that water quality will not be adversely affected by deeming facilities as the equivalent of secondary treatment (see 40 CFR 122.44 at 48 FR 14169, and 40 CFR 124.53.)

4. Alternative State Requirements

The final rule allows States to recommend (subject to public comment and EPA approval) alternative requirements for the 30-day and 7-day effluent BOD_5 and SS concentrations based on effluent concentrations consistently achieved through proper operation and maintenance of the "median" facility in a statistically representative sample of facilities within a State or appropriate contiguous geographical area meeting the definition of "facilities eligible for treatment equivalent to secondary treatment" (§ 133.105(d)). The rationale is the Congressional intent that the Administrator should take into account geographic, seasonal and climatic conditions affecting plant performance. Guidance for implementing these provisions is contained in Section VII of this document.

C. IMPACT OF REGULATION

1. Number of Facilities Eligible

It is estimated that there are between 1700 and 2670 existing rock and plastic media trickling filters, and between 4050 and 6650 waste stabilization ponds that provide biological treatment of municipal wastewater. Of these facilities, it is further estimated that a maximum of 3900 facilities would be potentially eligible for permit adjustments.

2. Cost Impacts

In order for the estimated 3900 facilities to meet current secondary treatment requirments it is further estimated that capital costs of between $1 billion and $3 billion would be required for trickling filter facilities, with approximately $2 billion needed for waste stabilization ponds. Under this rule implementing Section 304(d)(4) of the Act, these costs would be deferred, reduced or eliminated. The total cost savings over a 20-year planning period is conservatively estimated at $1.6 billion.

3. Pollutant Loadings

It is estimated that the pollutant loading from trickling filter facilities is currently 994,000 pounds BOD_5 per day or approximately 181,400 tons BOD_5 per year. If all trickling filter facilities were to attain secondary treatment standards, it is estimated that that load would be reduced to approximately 750,000 pounds BOD_5 per day, or approximately 137,000 tons BOD_5 per year. Under this rule, moderate reductions in BOD_5 would occur, with the pollutant load estimated at 927,000 pounds BOD_5 per day, or approximately 169,200 tons BOD_5 per year.

SECTION II

INTRODUCTION

A. PURPOSE AND LEGAL AUTHORITY

Section 301(b)(1)(B) of the Clean Water Act (CWA or the Act), 33 U.S.C. Section 1311(b)(1)(B), requires that publicly owned treatment works (POTWs) achieve effluent limitations based upon secondary treatment as defined by the Administrator of the Environmental Protection Agency (EPA) pursuant to Section 304(d)(1) of the Act. Section 402(a)(1) of the Act authorized the setting of requirements for direct dischargers on a case-by-case basis; however, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator. Section 304(d)(1), 33 U.S.C. Section 1314(d)(1), requires that the Administrator publish information on the degree of effluent reduction attainable through the application of secondary treatment within sixty days of enactment and from time to time thereafter. Section 304(d)(4) of the Act, 33 U.S.C. § 1314(d)(4), as amended by section 23 of the "Municipal Wastewater Treatment Construction Grant Amendments of 1981" (P.L. 97-117), deems biological treatment facilities such as oxidation ponds, lagoons, and ditches and trickling filters as the equivalent of secondary treatment, and further directs the Administrator to provide guidance under section 304(d)(1) on design criteria for such facilities, taking into account pollutant removal efficiencies. Section 304(d)(4) further requires that water quality not be adversely affected by deeming such facilities as the equivalent of secondary treatment.

The legislative history for section 23 shows that Congress was concerned that EPA had not "sanctioned" the use of certain biological treatment techniques that are effective in achieving significant reductions of BOD and SS for secondary treatment. The Senate Committee on Environment and Public Works reported that methods such as oxidation ponds and trickling filters are generally cheaper and more energy-efficient than "standard" methods, and that such technologies are particularly useful in smaller communities. The Senate Committee noted that "methods of achieving secondary treatment are also at the discretion of the Administrator," but concluded that EPA has not "sanctioned" the use of these methods (*i.e.*, oxidation ponds and trickling filters) for secondary treatment. Therefore, Section 304(d)(4) would permit "the use of certain biological treatment facilities to meet the secondary requirement provided that water quality and particularly the objective of the Act is not adversely affected, *in spite of the fact that they may not consistently meet 85 percent removal*." [S. Rep, No. 97-204, 97th Cong., 1st Sess. 18 (1981), emphasis added.]

The legislative history further suggests that the amendment would apply primarily to smaller communities, which could use trickling filters and waste stabilization ponds that are not capable of consistently meeting effluent limitations based on current secondary treatment requirements.

The enacted provisions contain language that requires the Administrator to provide criteria on the design and pollutant removal efficiencies of such biological treatment facilities, in accordance with the Administrator's existing authority to define the degree of effluent reduction attainable through secondary treatment [§ 304(d)(1) of the Act]. In implementing these provisions, the Administrator is directed to

> take into account not only pollutant removal efficiencies, but also differing geographical/climatic conditions which affect treatment plant performance. The Administrator should also address the seasonal and geographical variability of biological treatment plant performance in the regulations issued to carry out this section. [S. Rep. No. 97-204, 97th Cong., 1st Sess. 18 (1981)]

In addressing water quality issues, the legislative history clearly rejects the use of receiving water quality as a factor in setting effluent limitations when using the technology-based standard. The report of the House Subcommittee on Investigations and Oversight stated that "prior to enactment of the 1972 Federal Water Pollution Control Act Amendments, which set out a technology based requirement that all communities have, as a minimum, secondary treatment, municipal (and industrial) treatment requirements were generally established on the basis of assessing a stream's assimilative capacity. Unfortunately, this water quality-based approach was, and still is, too vague and subject to analytical weaknesses" [H.R. Rep. No. 97-30, 97th Cong., 1st Sess. 35 (1981)].

The Senate Report stated that "although water quality impact is not a consideration in defining technology-based regulations, a technology would not be acceptable for any category of dischargers if it is found that the technology is inadequate in terms of necessary water quality protection" [S. Rep. No. 97-204, 97th Cong., 1st Sess. 18 (1981)].

In response to these requirements, the secondary treatment regulation has been reviewed and amended. This document provides the technical basis for amendments to the regulation. Appendix B of this document contains relevant sections of the legislative history for Section 304(d)(4) of the Act.

B. PRIOR EPA REGULATIONS

The secondary treatment regulation was originally promulgated on August 17, 1973 [38 FR 222981]. Generally, it established levels of effluent quality for the parameters biochemical oxygen demand (five day), (BOD_5), suspended solids (SS), fecal coliform bacteria, and pH. Special consideration was provided for facilities subject to wet weather flows from combined sanitary and storm sewers, and facilities receiving high strength industrial wastes. The technical support for those regulations was contained in "Effluent Limitations by the Application of Secondary Treatment," Contract No. 68-01-0346, November 1972.

The regulation did not require the use of any given treatment technology to meet the requirements; however, guidance was provided by the Administrator under Section 304(d)(2) and 304(d)(3) of the Act. Those documents, "Alternative Waste Management Techniques for Best Practicable Waste Treatment" (Ref. 13) and "Innovative and Alternative Technology Assessment Manual" (Ref. 14), indicated a range of treatment processes which had been proven capable of achieving secondary treatment.

Two subsequent amendments promulgated on July 26, 1976 [41 FR 307881] and October 7, 1977 [42 FR 5665] provided for: (1) deletion of the fecal coliform bacteria limitations and clarification of the pH requirement, and (2) special consideration for the suspended solids effluent limitations applicable to waste stabilization ponds with wastewater flows of less than 2 million gallons per day (MGD).

The current secondary treatment regulation defines "secondary treatment" (Section 133.102) as attaining an average effluent quality for both BOD_5 and SS of 30 milligrams per liter (mg/L) in a period of 30 consecutive days, an average effluent quality of 45 mg/L for the same pollutants in a period of 7 consecutive days, and 85 percent removal of the same pollutants in a period of 30 consecutive days. The effluent values for pH must be maintained between 6.0 and 9.0 unless certain demonstrations are made.

The regulation provides special consideration in three instances:

(1) where secondary treatment works are affected by wet weather flows due to combined sewers, the percentage removal requirements may be adjusted (Section 133.103(a)),

(2) where industrial contributions exceed 10 percent of the design flow, and the discharge of BOD_5 and SS by the industrial contributor permitted under sections 301(b)(1)(A)(i) or 306 of the Act would be less stringent than secondary treatment requirements, the 30-day and 7-day requirements for BOD_5 and SS may be adjusted (§ 133.103(b)), and

(3) where waste stabilization ponds are the sole process used for secondary treatment and wastewater flows are less than 2 MGD, Regional Administrators and State Directors are authorized to adjust the SS effluent limitations to reflect the effluent quality achieved 90 percent of the time within a specific geographic area (§ 133.103(c)).

The regulation (§ 133.104(a)) requires the use of sampling and testing procedures for BOD_5 and SS specified in guidelines promulgated pursuant to §§ 304(h) and 402 of the Act (40 CFR Part 136). The regulation also allows use of chemical oxygen demand (COD) or total organic carbon (TOC) testing as a substitute for BOD_5 when a long-term BOD:COD or BOD:TOC correlation can be made (§ 133.104(b)).

C. SCOPE OF THIS RULEMAKING

In this rulemaking, EPA's efforts have been directed towards amending the secondary treatment regulation in accordance with provisions of Section 304(d)(4) of the Act. That latest amendment to the secondary treatment requirements of the Act, Section 23 of P.L. 97-117, deems such biological treatment facilities as oxidation ponds, lagoons, and ditches and trickling filters as the equivalent of secondary treatment, and further directs the Administrator to provide guidance under § 304(d)(1) on design criteria for such facilities, taking into account pollutant removal efficiencies. § 304(d)(4) further requires that water quality not be adversely affected by deeming such facilities the equivalent of secondary treatment.

D. SUMMARY OF DATA COLLECTION AND SAMPLING EFFORTS

The data collection and sampling efforts summarized in this document were carried out, in part, under Contract No. 68-01-6275 with Hazen & Sawyer, P.C., New York, New York. Copies of the contractor's task reports are available for public inspection at: Central Docket Section, Gallery 1, West Tower Lobby, Environmental Protection Agency, 401 M Street, S.W., Washington, D. C. between the hours of 8:00 a.m. and 4:30 p.m., business days.

1. Introduction

The data and analyses contained in this document were based on actual performance data from 416 representative treatment plants in eight process categories. The eight processes included in the study were:

- Trickling filter - rock media
- Trickling filter - plastic media
- Conventional activated sludge
- Contact stabilization-activated sludge
- Extended aeration-activated sludge
- Rotating biological contactors
- Oxidation ditch
- Stabilization pond

Data for this study were acquired from a wide range of secondary wastewater treatment facilities located throughout the United States. A sample population of forty (40) plants per process category was adopted as the optimum goal for statistical analysis and reliability. Daily operating data for the representative plants were compiled in a computerized data management system to permit rapid calculations and statistical analysis.

2. Identification of Treatment Facilities

Identification of potential treatment plants to be surveyed was based on the 1982 Environmental Protection Agency (EPA) Municipal Needs Survey (Ref. 18) computer printout of all municipal wastewater treatment plants in the nation. This listing contains information on the nature and location of each facility, process type, actual and design flows, organic loadings, NPDES criteria, and extent of industrial contributions. The Needs Survey listed approximately 23,000 plants for consideration.

The following criteria were used in screening the Needs Survey data to identify potential members of the sample population:

- Flow - Operating flow between 30 and 120 percent of design flow, with industrial flow less than 15 percent of design flow to eliminate plants that are severely underloaded or overloaded or have high industrial contributions.

- Organic Loading - Organic loading data in the Needs data base was inconclusive. In some instances facilities having atypically high organic loadings were selectively eliminated.

- Process - Only facilities with a single secondary process were included. Those facilities that were designed to provide nitrification as part of the same or add-on processes were excluded because such processes provide an advanced level of treatment beyond secondary treatment.

- Temperature - Facilities were chosen equally from states with warm and cold winters.

- Monitoring - Availability and quality of the general operating data was considered.

3. Initial and Final State Surveys

Following the inital screening of Needs Survey data, five states (Michigan, New York, Texas, Florida and Virginia) were selected for preliminarily identifying treatment facilities based upon the quality of the operating data and climatic distribution. This process produced a total of 1,193 plants for consideration. Approximately 75% or 900 plants had flows of less than 1 MGD (minor facilities). The remaining 293 plants were 1 MGD or larger (major facilities).

After this identification, plant operating data were obtained from each of the five States. Those plants were screened for poor performance and noncontinuous data at the State offices and copies of the plant performance data were obtained for the remaining selected plants. Only 22% or 262 plants out of the identified 1,193 were considered suitable for inclusion in the sample population.

The Needs Survey screening criteria were then applied to Needs Survey data for the remaining 43 states (except Hawaii and Alaska) to identify sufficient plants to complete the eight process categories and two plant size classes. Telephone discussions were used to narrow down the number of states to be contacted on the second and final round of data gathering. Seven additional states (Wisconsin, North Carolina, Oklahoma, Tennessee, Kansas, Indiana and Iowa) were contacted by telephone and agreed to forward operating data together with design information.

Information from a total of 416 plants was received and utilized in the study. Table II-1 lists the facilities by state, process category, and size. The targeted number of plants with adequate data were not found for: (1) plastic media trickling filters and extended aeration, (2) the category of activated sludge for minor facilities, a process seldom used in small plants, and (3) the category of rotating biological contractors and waste stabilization ponds for major facilities, processes seldom used in large plants.

4. Data Coding, Checking, and Formating

Computerization of treatment facility data involved transfer of the plant operating data into a universal computer input format suitable for statistical analysis. The sequential steps followed in creating the computer data base included 1) coding the plant operating logs and keypunching, 2) checking and editing, and 3) computer manipulation of the data into a single universal format.

The plant operating logs included two years of operating data originally supplied by the plant operator. Each plant was coded by state, process type, facility, identification number, and plant size. A "header" card containing the facility code number, facility name, State, process code, had design flow, design biochemical oxygen demand (BOD_5) and suspended solids (SS) concentrations, process volume, stabilization pond volume and clarifier surface area was prepared for each set of plant data. Daily data from facility operating logs were then entered for each facility, and a computer listing of daily observations generated. Discrepancies between the computer listing and the operating logs were edited by hand on the computer listing and corrected on the active computer file.

The active computer file was transformed into a universal data format acceptable to the Statistical Analysis System (SAS) package for inconsistencies in the data and edited on line.

5. Screening Criteria for Outlier Identification and Elimination

Because the objective in this study was to determine what performance can be expected from a well operated wastewater treatment plant, an important part of the data collection and sampling effort was to exclude plants where poor performance could be traced to unacceptable design or operating deficiencies, and plants where exceptionally good performance resulted from atypical loadings or extra unit processes, especially since these would not always be noted in the Needs classification. Causes for outlying values showing poor or exceptional overall plant performance were identified on a plant-by-plant basis to determine whether or not such performance should be reasonably considered in establishing technology-based effluent limitations. Outliers were not eliminated from the data simply because their values were different than expected, but only if the value resulted from such causes as poor design, over or underloadings, accidents, sampling errors, or additional treatment process. Otherwise the screening may result in discarding true values of process performance and effluent characteristics.

a. Poor Performers. The outlier identification screening attempted to identify two types of poor performing outliers: 1) those plants with consistently poor performance, i.e., monthly average effluent concentrations that frequently exceed the monthly secondary treatment standard, which were caused by inadequate design or operation; and 2) those plants with short term, high effluent values, which may result in a violation of the monthly standard, which could be attributed to mechanical failures, inadequate process control, errors in sampling or other unexpected causes. In both cases, such outliers could strongly affect the statistical results and give misleading conclusions about process performance. A plant was excluded based on the reasons presented below, if the problems were consistently apparent.

- Poor operator application of concepts and testing to process control
- Inadequate sewage treatment understanding
- Improper technical guidance (design engineer, State and Federal personnel)
- Hydraulically underloaded/overloaded
- Inadequate sludge wasting capability
- Inadequate process flexibility (includes equipment failures)
- Inadequate process controllability
- Secondary clarifier problems
- Inadequate sludge treatment
- Inadequate aerator capability
- Infiltration/Inflow (I/I)
- Inadequate process control testing procedures
- Inadequacy of O&M Manual
- High industrial loading
- Inadequate training of plant personnel

b. Exceptional Performers. The outlier identification screening also attempted to identify plants that reflect exceptional performance, due to special loadings or extra processes. Since such performance cannot be considered typical of a process category, such plants were removed from the data base.

c. Elimination Screening Procedure. The steps used to identify which plants would be excluded from the data base were as follows:

- Monthly average BOD and SS effluent concentration from each plant were computed for the full 2 years of records.

- Plants identified for follow-up investigation were those plants having annual average effluents greater than 30 mg/L and the five plants showing the consistently best effluent quality values.

- Original operating logs and in-house design data and permit information were reviewed for recorded comments that would explain the unusual performance or identify any unusual or design/process limitations.

- A list was compiled of "reasons" for unusual plant performance.

- "Reasons" for unusual performance were verified with the plant operator. It was also determined whether short-term, abnormal conditions existed and if the bulk of the effluent data could be retained.

The results for each process category were tabulated and specific recommendations made toward the final choice of outliers. Table II-2 lists the number of outliers identified in each process category.

The distribution of the final facilities selected by state is shown in Table II-3. The distribution of the final facilities by design flow, percent hydraulic loading, percent BOD_5 and SS organic loading is given in Tables II-4 through II-7, respectively.

TABLE II-1

FACILITIES SELECTED FOR THE SECONDARY TREATMENT PLANT PERFORMANCE STUDY

State/Source	Process Size	Trickling Filters		Activated Sludge			Rotating Biological Contactors	Oxidation Ditch	Stabilization Ponds	State Total
		Rock	Plastic	Conventional	Contact Stabilization	Extended Aeration				
Florida	Minor	3	-	3	4	4	-	1	-	15
	Major	3	-	11	7	-	-	1	-	22
Michigan	Minor	8	5	9	1	-	3	-	24	50
	Major	2	7	20	3	1	8	-	-	41
New York	Minor	7	-	1	6	6	2	2	-	24
	Major	9	1	7	3	1	1	1	-	23
Texas	Minor	1	-	-	1	-	-	-	-	2
	Major	4	-	3	1	-	-	5	-	13
Virginia	Minor	4	1	-	4	5	-	-	8	22
	Major	8	-	12	1	-	1	-	-	22
Wisconsin	Minor	6	-	12	12	4	4	-	1	39
	Major	-	1	2	2	-	1	-	-	6
North Carolina	Minor	1	-	-	-	-	-	-	6	7
	Major	7	-	1	-	2	-	-	-	10
Oklahoma	Minor	-	-	-	-	-	1	1	-	2
	Major	4	1	1	2	1	-	-	-	9
Tennessee	Minor	3	-	2	2	-	-	1	6	14
	Major	6	-	2	1	1	-	1	-	11
Kansas	Minor	4	-	-	7	3	1	4	-	19
	Major	2	-	2	2	-	-	1	-	7
Indiana	Minor	2	1	-	2	3	-	3	-	11
	Major	-	-	-	-	-	2	-	-	2

TABLE II-1 (Cont.)

FACILITIES SELECTED
FOR THE SECONDARY TREATMENT PLANT PERFORMANCE STUDY

State/Source	Process Size	Trickling Filters Rock	Trickling Filters Plastic	Activated Sludge Conventional	Activated Sludge Contact Stabilization	Activated Sludge Extended Aeration	Rotating Biological Contactors	Oxidation Ditch	Stabilization Ponds	State Total
Ohio	Minor	-	2	-	-	-	-	-	-	2
	Major	-	-	-	-	-	-	-	-	-
Washington	Minor	-	-	-	-	-	1	9	-	10
	Major	-	-	-	-	-	4	1	-	5
Oregon	Minor	-	-	-	-	-	3	-	-	3
	Major	-	-	-	-	-	-	-	-	-
Pennsylvania	Minor	-	-	-	-	-	-	-	-	-
	Major	-	-	-	-	-	1	-	-	1
Missouri	Minor	-	-	-	-	-	-	-	-	-
	Major	-	2	-	-	-	-	-	-	2
Minnesota	Minor	-	1	-	-	-	-	-	-	1
	Major	-	-	-	-	-	-	-	-	-
Iowa	Minor	7	-	-	3	2	3	-	-	15
	Major	3	1	-	1	-	1	-	-	6
Subtotal	Minor	46	10	27	42	27	18	21	45	236
Subtotal	Major	48	13	61	23	6	19	10	0	180
Process Totals		94	23	88	65	33	37	31	45	416

TABLE II-2

ELIMINATION OF OUTLIERS FROM DATABASE: SUMMARY BY PROCESS CATEGORY

Process Category	Original Number of Facilities In Data Base	Outliers (1) Poor Performance	Outliers (2) Special Unit Process	Number of Facilities Remaining In Database	Percent Retained
Trickling Filter-Rock	94	12	18	64(3)	68.1
Trickling Filter-Plastic	23	4	2(4)	17	73.9
Activated Sludge Conventional	88	15	7	66	75.0
Activated Sludge Contract Stabilization	65	4	4	57	87.7
Activated Sludge Extended Aeration	33	4	1	28	84.8
Rotating Biological Contactors	37	4	6(4)	27	73.0
Oxidation Ditch	31	2	1	28	90.3
Stabilization Pond	45	8	-	37	82.2
TOTAL	416	53	39	324	77.9

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(1) Plants having primary treatment only or identified design/operation problems

(2) Chemical addition, final effluent polishing ponds, effluent filters, or two-stage operation

(3) Only 61 had usable TSS data.

(4) Because of a small number of plants in these categories, plants using chemical addition in primary clarifiers for P removal were left in the data base (i.e., were not taken as outliers).

TABLE II-3

DISTRIBUTION OF SELECTED FACILITIES BY STATE

	Trickling Filters			Act. Sludge		RBC	Oxid.	Stab.	All
State	Rock	Plastic	Conv.	Cont. Stab.	Ext. Aer.		Ditch	Pond	Processes
Florida	1	-	11	8	4	-	2	-	26
Indiana	1	-	-	2	3	2	2	-	10
Iowa	10	-	-	3	2	3	-	-	18
Kansas	6	-	1	9	1	-	5	-	22
Michigan	1	9	21	4	-	9	-	22	66
Minnesota	-	1	-	-	-	-	-	-	1
Missouri	-	2	-	-	-	-	-	-	2
New York	14	-	7	8	7	1	2	-	39
North Carolina	7	-	-	-	2	-	-	4	13
Ohio	-	2	-	-	-	-	-	-	2
Oklahoma	2	1	1	1	1	-	-	-	6
Oregon	-	-	-	-	-	2	-	-	2
Pennsylvania	-	-	-	-	-	1	-	-	1
Tennessee	8	-	2	3	1	-	2	5	21
Texas	2	-	3	2	-	-	5	-	12
Virginia	9	1	10	5	5	1	-	5	36
Washington	-	-	-	-	-	4	10	-	14
Wisconsin	3	1	10	12	2	4	-	1	33
	64	17	66	57	28	27	28	37	324

TABLE II-4

DISTRIBUTION OF SELECTED FACILITIES BY DESIGN FLOW

	Design Flow (mgd)							
Process Category	<0.25	0.25-1.0	Minor (<1.0) Subtotal	1.0-5.0	5.0-20.0	>20.0	Major (>1.0) Subtotal	All Facilities
Trickling Filter - Rock	11	18	29	26	9	0	35	64
Trickling Filter - Plastic	1	6	7	8	2	0	10	17
Activated Sludge - Conventional	5	12	17	24	20	5	49	66
Activated Sludge - Contact Stabilization	13	26	39	13	3	2	18	57
Activated Sludge - Extended Aeration	17	7	24	2	2	0	4	28
RBC	3	8	11	13	2	1	16	27
Oxidation Ditch	13	5	18	10	0	0	10	28
Stabilization Pond	28	9	37	0	0	0	0	37
All Categories	91	91	182	96	38	8	142	324

TABLE II-5

DISTRIBUTION OF SELECTED FACILITIES BY HYDRAULIC LOADING RATE

Process Category	Avg. Flow	Number of Facilities Within Range of Actual Influent Values as a Percentage of Design Loading									All Plants	Missing Info.	Total Plants
		< 50%	50-60	60-70	70-80	80-90	90-100	100-110	110-120	> 120%			
Trickling Filter-Rock		7	9	9	11	7	5	2	4	8	62	2	64
Trickling Filter-Plastic		2	2	2	5	2	0	0	0	4	17	0	17
Act. Sludge Conventional		12	5	9	8	12	7	4	5	4	66	0	66
Act. Sludge Cont. Stab.		12	8	8	7	7	5	2	3	5	57	0	57
Act. Sludge Ext. Aeration		10	3	1	2	3	6	2	1	0	28	0	28
R.B.C.		6	9	1	2	3	3	1	1	1	27	0	27
Oxidation Ditch		11	4	2	5	2	0	0	2	2	28	0	28
Stabilization Pond		3	1	1	2	1	0	1	1	20	30	7	37
TOTALS		63	41	33	42	37	26	12	17	44	315	9	324

TABLE II-6

DISTRIBUTION OF SELECTED FACILITIES BY ORGANIC (BOD) LOADING RATE

Process Category	Avg. Load	Number of Facilities Within Range of Actual Influent Values as a Percentage of Design Loading									All Plants	Missing Info.	Total Plants
		<50%	50-60	60-70	70-80	80-90	90-100	100-110	110-120	>120%			
Trickling Filter-Rock		21	6	7	4	0	6	1	2	2	49	15	64
Trickling Filter-Plastic		11	1	1	1	1	0	0	0	1	16	1	17
Act. Sludge Conventional		28	7	4	7	4	4	8	2	0	64	2	66
Act. Sludge Cont. Stab.		16	11	7	6	5	3	0	3	1	52	5	57
Act. Sludge Ext. Aeration		16	3	3	3	1	2	0	0	0	28	0	28
R.B.C.		18	3	1	1	2	1	1	0	0	27	0	27
Oxidation Ditch		15	2	3	3	1	0	1	1	2	28	0	28
Stabilization Pond		3	0	1	0	1	1	0	0	0	6	31	37
TOTALS		128	33	27	25	15	17	11	8	6	270	54	324

TABLE II-7

DISTRIBUTION OF SELECTED FACILITIES BY SOLIDS (TSS) LOADING RATE

Process Category	Avg. Load	Number of Facilities Within Range of Actual Influent Values as a Percentage of Design Loading									All Plants	Missing Info.	Total Plants
		<50%	50-60	60-70	70-80	80-90	90-100	100-110	110-120	>120%			
Trickling Filter-Rock		16	3	2	4	1	1	1	0	0	28	36	64
Trickling Filter-Plastic		9	2	1	0	1	1	1	0	1	16	1	17
Act. Sludge Conventional		26	5	3	7	6	3	2	1	3	56	10	66
Act. Sludge Cont. Stab.		19	8	7	5	6	1	2	0	3	51	6	57
Act. Sludge Ext. Aeration		15	4	3	3	2	0	0	0	0	27	1	28
R.B.C.		15	3	2	1	2	1	1	1	1	27	0	27
Oxidation Ditch		12	5	4	1	3	0	1	0	2	28	0	28
Stabilization Pond		2	0	0	1	0	0	0	0	0	3	34	37
TOTALS		114	30	22	22	21	7	8	2	10	236	88	324

SECTION III

OVERVIEW OF MUNICIPAL WASTEWATER TREATMENT

A. BIOLOGICAL TREATMENT SYSTEMS FOR ACHIEVING SECONDARY TREATMENT

In 1975 EPA published "Alternative Waste Management Techniques for Best Practicable Waste Treatment" (Ref. 13), which identified three types of biological treatment systems for achieving secondary treatment: activated sludge, trickling filters, and ponds. All three types of biological treatment were in general use in 1975 and prior to the passage of P.L. 92-500 either as sole processes or in combination; however, the activated sludge process is by far the most typical or "standard" method in use [cf. S. Rep, No. 97-204, 97th Cong., 1st Sess. 18 (1981)].

Suspended growth type systems, including activated sludge, generally consist of an aerator and clarifier and are usually preceded by primary sedimentation. The aerator, utilizing air (either diffused or mechanical) or pure oxygen, provides conditions for a suspended microbial growth that metabolizes the biodegradable wastes. The microbial growth is clarified and a portion recycled to maintain metabolism in the aeration tankage. The other portion (the build-up of microbial growth) and the primary solids go to an appropriate solids-handling facility. There are many variants of activated sludge or suspended growth systems, including oxidation ditches.

Attached growth type systems, e.g., trickling filters, generally consist of a filter bed of rock or synthetic media and clarifier and are usually preceded by primary sedimentation. Biological treatment occurs in a manner similar to a suspended growth system, except the microbial growth is attached to a fixed medium over which wastewater is repeatedly recycled. The excessive microbial growth is sloughed off the media and captured in a clarifier. In addition to rock and plastic media trickling filters, attached growth type systems include variations such as rotating biological contactors.

Ponds, or waste stabilization pond type systems, consist of basins within which natural stabilization processes occur with any necessary oxygen provided by photosynthetic and/or mechnical sources. Waste stabilization ponds are commonly referred to as oxidation ponds or lagoons, and may stabilize wastes through aerobic metabolism, anaerobic metabolism, or both (facultative).

B. DESIGN, PERFORMANCE, AND RELIABILITY

In December 1980, the Agency published "Innovative and Alternative Technology Assessment Manual" (Ref. 14). The manual contains two-page fact sheets on various municipal treatment technologies, including biological treatment technologies. The fact sheets describe the treatment processes, process applicability, common process modifications, process limitations, performance and design criteria, construction and operation and maintenance cost curves, and process reliability. The fact sheets for selected biological treatment processes are reprinted in Appendix C of this document.

1. Activated Sludge

The manual fact sheets describe several activated sludge type technologies and their general design criteria. When the technology is applied to provide secondary treatment (as opposed to advanced treatment), the manual indicates that an effluent quality for BOD_5 and SS on the order of 20 mg/L, can be achieved. The percentage removal of BOD_5 and SS achieved by such facilities is characterized as between 85 percent and 90 percent. The manual describes the limitations for such systems in terms of operational complexity, high operating costs, and high energy consumption.

For oxidation ditches, the manual indicates that the process is highly reliable in achieving an effluent quality of 20 to 30 mg/L for BOD_5 and SS. Oxidation ditches are characterized as offering an added measure of reliability and performance over other biological treatment processes, but are subject to some of the same limitations that other activated sludge treatment processes face. The process cost of treatment is generally lower than other biological treatment processes in the range of wastewater flows between 0.1 and 10 mgd.

2. Trickling Filters

The manual fact sheets for trickling filter technologies provide general design criteria and describe the effluent quality attainable by such facilities in a range of 25 to 45 mg/L BOD_5 and 20 to 45 mg/L SS, depending of the type of trickling filter and operating conditions. For various trickling filter technologies, the manual indicates the following ranges of percentage removal of BOD_5 and SS: 80 to 90 percent, 60 to 80 percent, and 75 to 90 percent. In moderate climates, the processes are characterized as highly reliable; however, where wastewater temperatures fall below 13°C for prolonged periods, the process may experience reduced efficiency. The processes are consistently noted as mechanically reliable and simple to operate.

3. Waste Stabilization Ponds

The manual fact sheets for waste stabilization pond technologies indicate design criteria for ponds and describe the effluent quality attainable by various pond technologies in domestic waste applications as 25 to 30 mg/L BOD_5 and 20 to 150 mg/L SS. [Note: § 133.103(c) allows SS values less stringent than 30 mg/L.] Algae growth in the ponds is noted as affecting performance for SS removal. The manual notes that BOD_5 removal efficiencies of 75 to 95 percent have been reported for some waste stabilization ponds. The processes are described as highly reliable and require little operator expertise.

C. TYPES OF BIOLOGICAL TREATMENT SYSTEMS IN USE

Prior to the passage of the Act in 1972, the trickling filter and waste stabilization pond processes were extensively used for the treatment of municipal wastewater. As reflected in Table III-1, it was estimated that 4728 pond facilities and 4338 trickling filter facilities were in use in 1975, compared to only 2488 activated sludge and 1856 extended aeration facilities.

Since then, the suspended growth-activated sludge systems have been widely used as the "typical" or "standard" biological treatment method for achieving secondary treatment. Only an estimated 281 trickling filter facilities were constructed after 1973, while approximately 1100 of the waste stabilization ponds were constructed. As shown in Table III-2, when pond facilities are excluded, nearly 90 percent of the secondary treatment facilities put in place since 1973 have used some form of suspended growth system.

EPA believes that the limited number of trickling filter facilities constructed following the passage of P.L. 92-500 and EPA's promulgation of the secondary treatment requirements can be attributed in part to a general awareness that the level of effluent quality consistently achieved by trickling filter facilities is poorer than that consistently achieved by activated sludge type facilities. Although the cited biological treatment techniques were identified in the October 1975 BPWTT document as being capable of meeting current secondary treatment requirements, the ranges of design loadings (or other design criteria) for trickling filters would often result in more costly facilities than facilities constructed in accordance with designs for trickling filters that typically existed prior to passage of P.L. 92-500.

The 1982 Needs Survey indicates that approximately 2670 trickling filters and approximately 6650 pond facilities are now in use. As indicated in Table III-3, 1480 trickling filters and 2435 ponds are projected to require changes in treatment process by the Year 2000. As further indicated in Table III-4, the 1982 Needs Survey projects that the overall number of trickling filter facilities in use in the Year 2000 will decline from 2670 to approximately 1900 facilities. This decline can be attributed primarily to abandonment and replacement of existing trickling filter facilities in favor or other treatment process types.

In conclusion, the changes in use patterns since 1973, and the projected use patterns, would indicate that the current secondary treatment standard has discouraged the use of trickling filters.

TABLE III-1

ESTIMATED DISTRIBUTION OF PUBLICLY-OWNED TREATMENT WORKS AS OF OCTOBER 1975

	Major Plants (1 MGD or more)			Minor Plants (1 MGD or less)		
	WQL[a]	EL[b]	EL-OO[c]	WQL	EL	Total
None	29	32	3	944	1,462	2,467
Primary	549	366	62	828	1,278	3,022
Pond	87	50	7	1,800	2,791	4,728
Trickling Filter	574	382	57	1,367	2,015	4,338
Activated Sludge	235	219	35	872	1,162	2,488
Extended Aeration	42	29	4	686	1,071	1,828
Secondary-Other	112	77	13	518	879	1,586
Land Disposal	5	3	–	58	91	157
Tertiary	42	30	4	169	263	504
Total	1,676	1,188	185	7,242	11,012	21,118

[a] Plants located on water-quality-limited segments.
[b] Plants located on effluent-limited segments.
[c] Plants located on effluent-limited segments with ocean outfalls.

SOURCE: EPA-430/9-75-013, October 1975

TABLE III-2-A

ESTIMATED NUMBER OF SECONDARY TREATMENT FACILITIES CONSTRUCTED UNDER P.L. 92-500

Process Type	Number	% of Total	% of Total (excluding Waste Stabilization Ponds)
Trickling Filter	281	8%	11%
Waste Stabilization Pond	1104	31%	---
Activated Sludge	1483	42%	61%
Other	687	19%	28%
Total	3555		

SOURCE: Grants Information Control System, as of April 29, 1983.

TABLE III-2-B

DISTRIBUTION OF WASTEWATER TREATMENT PLANT PROJECTS BY TREATMENT PROCESS [1]

Process Type	Number (1980)	% of Total	Number (1983)	%of Total
Trickling Filter	47	6%	(2)	--
Pond	114	16%	431	27%
Activated Sludge	347	47%	526	33%
Oxidation Ditch	(3)	---	154	10%
RBCs	20	3%	69	4%
Other	209 [3]	28%	405 [2]	26%
TOTALS	737	100%	1585	100%

SOURCE: Construction Costs for Municipal Wastewater Treatment Plants:
1973-1978, EPA-430/9-80-003, April 1980, Table 2.2;
1973-1982, EPA-430/9-83-004, June 1983, Table 2.2

(1) 1983 report represents data from 30% of P.L. 92-500 funded facilities included in $8.5 billion of Federal grants.
1980 report represents data from over half of P.L. 92-500 funded facilities at that time.

(2) Included in "Other," separate break-out not available. Estimate number of trickling filters as of 1983 as 7% of total.

(3) Included in "Other," separate break-out not available. Estimate number of oxidation ditches in 1978 as 8% of total.

TABLE III-3

ESTIMATED NUMBER OF TRICKLING FILTERS AND POND-TYPE FACILITIES NOW IN USE BY PROPOSED CHANGE

Proposed Change	Trickling Filters		Ponds	
No Change [1]	1190		4215	
Change	1480		2435	
- Upgrade		(275)		(630)
- Upgrade/Enlarge		(200)		(450)
- Replace/Abandon		(1005)		(1355)
TOTALS	2670		6650	

SOURCE: 1982 Needs Survey: Conveyance, Treatment, and Control of Municipal Wastewater, Combined Sewer Overflows, and Stormwater Runoff, Summaries of Technical Data. USEPA, Washington, D.C. EPA-430/19-83-002, June 1983. Tables 42-10, 42-11, 42-12, 42-13, 42-57, 42-58.

TABLE III-4

YEAR 2000 ESTIMATE OF DISTRIBUTION OF TREATMENT PROCESSES, BY DESIGN CAPACITY AND EPA REGION

EPA REGION & FLOW RANGE (MGD)	ALL PLANTS		LAGOONS		LAND TREATMENT		ACTIVATED SLUDGE		OXIDATION DITCH		TRICKLING FILTER		RBC		OTHER	
	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW	# OF PLANTS	TOTAL FLOW
0.00- 0.10	187	10.2	59	3.3	26	1.2	55	3.3	4	0.4	1	0.1	7	0.4	54	2.9
0.11- 0.50	208	55.1	65	15.9	10	2.6	96	26.9	16	4.3	3	1.2	6	1.8	27	5.9
0.51- 1.00	71	50.5	12	7.9	3	1.9	42	30.7	6	4.0	3	2.3	8	6.6	3	1.8
1.01-10.00	210	691.6	21	50.3	2	3.0	156	533.0	2	5.4	25	94.5	20	68.2	1	6.1
10.01 +	50	1678.7	0	0.0	0	0.0	48	1654.8	0	0.0	5	66.0	3	104.6	0	0.0
REGION I	726	2486.0	157	77.3	41	8.4	397	2248.5	28	13.8	37	163.9	44	181.4	85	16.5
0.00- 0.10	267	14.4	164	8.7	0	0.0	76	4.7	2	0.2	3	0.2	2	0.1	31	1.3
0.11- 0.50	324	81.1	126	25.3	3	1.0	150	42.2	12	2.8	43	12.9	19	6.0	7	1.6
0.51- 1.00	118	89.6	18	14.3	3	2.3	70	52.3	8	6.4	29	21.8	6	4.9	2	1.7
1.01-10.00	263	960.2	34	133.1	2	13.5	177	678.3	6	19.2	67	230.5	19	66.1	2	3.9
10.01 +	82	4344.7	3	400.0	0	0.0	74	4185.9	2	38.0	7	139.7	3	54.9	0	0.0
REGION II	1,054	5489.8	345	581.3	8	16.7	547	4963.2	30	66.4	149	404.9	49	131.8	42	8.4
0.00- 0.10	803	44.0	470	26.2	11	0.5	283	15.4	10	0.8	10	0.7	4	0.3	35	1.4
0.11- 0.50	896	228.7	314	61.3	13	3.3	487	137.7	28	9.1	39	12.9	23	7.4	30	8.7
0.51- 1.00	239	176.4	18	13.7	4	2.8	192	140.5	11	8.5	24	18.4	14	11.9	1	0.6
1.01-10.00	351	1056.1	13	26.1	3	10.2	259	809.8	6	12.1	77	238.0	33	89.6	2	12.3
10.01 +	62	2869.0	6	204.2	0	0.0	59	2759.5	0	0.0	5	328.5	3	320.4	0	0.0
REGION III	2,351	4373.9	821	331.3	31	16.6	1,280	3862.6	55	30.5	155	598.3	77	429.5	68	22.8
0.00- 0.10	1,077	51.2	512	23.6	21	1.4	568	28.0	10	0.9	5	0.4	6	0.5	6	0.2
0.11- 0.50	1,014	248.0	440	103.0	62	14.7	542	134.4	49	14.4	36	11.9	23	6.5	3	0.6
0.51- 1.00	308	229.0	100	73.7	21	15.7	196	148.9	22	15.8	39	28.6	20	14.3	0	0.0
1.01-10.00	655	2277.8	135	426.9	61	241.2	468	1682.8	38	117.8	175	648.4	46	152.5	4	23.3
10.01 +	126	3967.2	23	584.7	7	150.1	114	3586.1	1	12.0	27	620.8	8	173.2	1	11.4
REGION IV	3,180	6773.1	1,210	1211.6	172	422.8	1,888	5579.9	120	160.7	282	1309.9	103	346.7	14	35.4
0.00- 0.10	1,418	79.1	916	51.6	73	4.3	444	24.9	34	2.4	41	3.0	16	1.3	36	1.2
0.11- 0.50	1,369	333.8	722	164.3	79	18.4	511	131.5	104	25.9	169	49.7	84	26.3	5	1.3
0.51- 1.00	351	256.4	109	79.2	16	10.7	192	142.9	18	12.6	80	58.0	47	34.4	1	0.8
1.01-10.00	586	1822.2	90	226.5	12	21.4	430	1415.7	17	35.1	123	367.8	81	243.2	0	0.0
10.01 +	140	7702.6	10	231.8	1	52.0	122	7245.9	2	27.5	25	836.1	7	126.9	2	68.2
REGION V	3,864	10193.9	1,847	753.3	151	106.6	1,699	8960.7	175	103.3	438	1314.3	235	432.1	44	71.4
0.00- 0.10	1,797	84.7	1,374	63.5	146	7.1	292	13.2	182	10.6	4	0.3	1	0.1	2	0.2
0.11- 0.50	1,198	289.7	649	145.4	150	37.4	374	98.1	198	52.1	46	14.5	2	0.7	2	0.7
0.51- 1.00	356	265.6	100	73.4	33	23.3	151	114.8	105	76.1	50	40.1	7	5.3	0	0.0
1.01-10.00	475	1441.7	112	310.0	38	97.3	258	848.6	68	172.2	117	376.1	11	56.2	1	6.0
10.01 +	67	2140.7	9	173.5	3	51.9	51	1888.4	5	75.7	16	574.4	5	66.7	0	0.0
REGION VI	3,893	4222.2	2,244	765.6	370	216.8	1,126	2962.9	558	386.5	233	1005.2	26	128.9	5	6.8
0.00- 0.10	1,445	65.6	1,278	55.3	15	0.9	107	6.0	29	2.1	58	3.9	3	0.3	0	0.0
0.11- 0.50	687	160.8	378	81.0	21	5.5	103	25.7	108	28.4	122	31.3	48	14.1	2	0.5
0.51- 1.00	143	102.3	50	35.0	4	2.8	39	29.5	32	22.7	37	25.9	14	10.3	0	0.0
1.01-10.00	186	561.5	31	82.2	3	8.6	59	236.5	21	42.5	79	237.5	30	76.6	1	1.4
10.01 +	32	1139.8	3	178.7	0	0.0	26	985.3	0	0.0	14	387.2	1	52.0	0	0.0
REGION VII	2,493	2029.8	1,742	431.9	43	17.6	334	1282.9	190	95.6	310	685.6	96	153.1	3	1.9
0.00- 0.10	771	31.0	740	29.7	20	0.7	31	1.4	5	0.4	2	0.2	1	0.1	2	0.1
0.11- 0.50	338	76.8	301	67.5	20	4.3	31	8.4	14	4.0	11	2.8	2	0.6	0	0.0
0.51- 1.00	69	49.7	49	34.6	3	2.1	12	9.4	8	6.0	5	3.8	2	1.2	0	0.0
1.01-10.00	137	411.2	62	169.0	10	34.3	46	148.6	15	43.0	36	136.0	12	35.5	0	0.0
10.01 +	19	664.0	3	54.4	2	24.7	10	384.5	0	0.0	10	308.8	1	18.5	0	0.0
REGION VIII	1,334	1232.5	1,155	355.0	55	65.9	130	552.3	42	53.3	64	449.3	18	55.8	2	0.1
0.00- 0.10	421	22.4	394	21.1	92	4.2	42	1.9	0	0.0	5	0.4	5	0.4	6	0.3
0.11- 0.50	371	90.5	319	75.1	113	30.1	74	21.8	10	3.6	18	5.4	6	1.6	0	0.0
0.51- 1.00	127	94.8	92	67.7	54	40.1	50	37.3	10	8.0	15	11.2	3	2.2	0	0.0
1.01-10.00	245	859.8	134	490.1	100	367.0	134	540.5	12	22.4	56	202.1	20	57.8	2	3.5
10.01 +	69	3323.6	18	471.6	17	463.3	48	2227.4	1	13.3	17	520.8	2	39.8	6	636.2
REGION IX	1,233	4390.7	957	1125.4	376	904.5	348	2828.8	33	47.2	111	739.6	36	101.6	14	639.9
0.00- 0.10	344	17.9	289	14.8	78	4.4	41	2.5	8	0.6	4	0.4	3	0.2	9	0.2
0.11- 0.50	298	74.8	145	32.3	51	12.1	113	30.8	31	8.5	23	7.3	8	2.0	3	0.9
0.51- 1.00	78	58.4	38	29.7	12	10.2	28	20.3	10	7.0	18	13.9	3	2.3	0	0.0
1.01-10.00	152	508.3	40	116.2	18	54.6	82	298.4	8	14.6	35	144.0	17	47.4	1	4.0
0.01 +	27	887.0	3	83.0	2	30.3	20	586.3	0	0.0	6	139.8	1	11.7	1	175.0
REGION X	899	1546.1	515	275.8	161	111.5	284	938.1	57	30.5	86	305.3	32	63.5	14	180.1
0.00- 0.10	8,530	420.1	6,196	297.4	482	24.4	1,939	100.9	284	18.0	133	9.1	48	3.2	181	7.5
0.11- 0.50	6,703	1638.8	3,459	770.6	522	128.7	2,481	657.1	570	152.5	510	149.3	221	66.6	79	19.9
0.51- 1.00	1,860	1372.3	586	428.8	153	111.2	972	726.1	230	166.6	300	223.7	124	93.0	7	4.1
1.01-10.00	3,260	10589.9	672	2029.8	249	850.7	2,069	7191.9	193	483.8	790	2672.6	289	892.6	14	60.1
10.01 +	674	28716.6	80	2381.6	32	772.2	572	25504	11	166.5	132	3921.5	34	968.6	10	890.8
ALL REGIONS	21,027	42737.5	10,993	5908.0	1,438	1887.0	8,033	34179	1,288	987.2	1,865	6975.8	716	2023.9	291	983.0

SOURCE: EPA-430/19-83-002, June, 1983, Table 46.

SECTION IV

PERFORMANCE CAPABILITIES OF BIOLOGICAL TREATMENT SYSTEMS

A. CHARACTERIZATION OF EFFLUENT DATA

To characterize the effluent BOD_5 and SS data for the treatment plants in this study (excluding outliers), summary statistics such as the mean, standard deviation, and skew coefficient were computed for daily and various average effluent concentrations from each plant. Also, several probability distribution functions were chosen as possible models of daily effluent data distributions and were tested using the Kolmogorov-Smirnov goodness-of-fit test. Details of these procedures are explained below.

1. Averaging Methods.

Several alternative averaging methods were considered: (1) running (*i.e.*, moving) versus calendar averaging, and (2) geometric versus arithmetic averaging. Use of moving averages increases the number of data points in the statistical analyses and hence the overall confidence in the results. A comparison of results obtained from calendar averages and moving averages was performed for various process categories. This comparison indicated that the differences in results using the two averaging periods were negligible in the majority of cases (see Table IV-1). A further comparison for the rock media trickling filter category indicated that the differences in results ranged from zero to a maximum of 11 percent, in terms of percentage of the facilities achieving a given effluent value (Tables IV-2 and Table IV-3). Thus moving averages were used in subsequent analyses. Arithmetic averaging was chosen over geometric averaging because the assumptions that must be made to justify the latter are not satisifed.

2. Basic Descriptive Statistics.

Descriptive statistics are useful in representing the essential features of the data in easily interpreted terms and for guiding later statistical analysis. The following summary statistics were used in this study to evaluate sample data:

- Arithmetic mean
- Median
- Mode
- Variance
- Standard deviation
- Coefficient of variation
- Skewness
- Minimum and maximum values

Examination of these statistics provides information on the central tendencies, ranges and shapes of the effluent BOD_5 and SS concentration distributions for data from each plant. The statistics were computed for various averaging periods including daily, weekly, monthly, seasonal yearly and for the overall period of record. In addition, 7-day moving and 30-day moving average statistics were computed. Table IV-4 summarizes by process category the statistical parameters of the effluent BOD and TSS and of the plant flow.

3. Probability Distribution.

Several probability distribution functions were tested to determine which would best describe daily effluent data distributions. Knowing the probability distribution of the daily treatment facility effluent data allows one to perform statistical analyses to predict plant performance at various confidence levels.

(a) Theoretical Distribution Models. Virtually an unlimited number of theoretical distribution functions could be tested for fit with the effluent data. Practical limitations prevent testing more than a few. The normal and log-normal distributions are very good candidates because of their simplicity, widespread use, and demonstrated usefulness in previous studies of wastewater treatment process performance.

(b) Empirical Distribution Models. Strong linear relationships between annual mean and percentile concentration values have been shown to exist in previous studies (Ref. 9, 10, 11, 12, 21, 24). For example, if one year's effluent BOD_5 data for a group of plants is placed in ascending order, the 95th percentile value will be approximately proportional to the plant's annual mean value. This model involving only the mean is called a one-parameter model. Where a model describes a linear relationship between mean effluent concentration and two parameters, the mean and the standard deviation it is called a two-parameter model.

The set of linear regression equations developed for the percentile values do not, by themselves, define a continuous probability distribution. However, given the mean value from a set of data, a finite number of predicted percentile values can be determined. A continous distribution can then be constructed by linearly interpolating between each of the predicted percentile values.

(c) Kolmogorov-Smirnov Goodness-of-Fit Test. The usefulness of each of the four (proposed) distribution functions for modeling BOD_5 and SS data from each plant was examined using the Kolmogorov-Smirnov goodness-of-fit test. The null hypothesis for this test is:

> "The observed data were sampled from an underlying population which is distributed according to the hypothesized distribution function."

It is assumed that if the test hypothesis is true, any differences between the observed distribution and the hypothesized distribution are due to the effects of random sampling.

(d) Comparison of Distribution Models. It has been shown in previous studies that no single probability distribution fits all plants well, i.e., the best form of the probability distribution varies from plant to plant. In this study, the Kolmogorov-Smirnov test determined that for rock media trickling filters, although no single distribution clearly fits the BOD_5 and SS data best in all cases, the log-normal distribution appears to fit more often than the normal distribution. The two-parameter empirical models also appear to fit the entire process category well on an overall basis and may be more useful than the log-normal distribution.

B. ANALYSIS OF VARIANCE AND COVARIANCE IN DATA BASE

1. Randomness of Effluent Data.

It is important to determine if effluent BOD_5 and TSS concentration data are random. Probability distribution models are based on the assumption that the data are independent and random. If this is not the case, the effect of nonrandom factors must be removed before calculating statistical parameters to be used in such models, and then allowed for separately when applying the models to predict performance. Because of the uncertainty as to the effect of nonrandomness on results using fitted probability distributions, actual data instead of probability distributions would be used in analyses if data prove to be nonrandom.

Randomness of treatment plant effluent data was investigated in detail for the trickling filter-rock media process category using both the runs test and serial correlation. The randomness of other process categories was investigated using less specific statistical tests.

The runs test is a general purpose test of randomness of a data series. Trend, grouping, and many types of cyclical movement in the data can be detected. In some cases, the runs test fails to detect dependence between successive values of a data series. It is therefore prudent to perform a test for correlation between consecutive data pairs (serial correlation) in addition to the runs test when examining data randomness.

The test for serial correlation is performed by treating the original data series as one variable, x_t, and treating the data series shifted forward one observation as the other variable, x_{t-1}. The Pearson correlation coefficient, a measure of association of the strength of the linear relationship between two variables, is then computed to test for correlation between x_t and x_{t-1}. If the data are random, the correlation coefficient will tend towards zero.

The results of the runs test on selected trickling filter plants are shown in Table IV-5, and the serial correlations for selected plants having daily data are shown in Table IV-6. These analyses show that BOD_5 and TSS data are highly nonrandom. Therefore, because the necessary assumptions for a probability model are not valid, actual effluent data were utilized in subsequent analyses.

2. Effects of Various Process Parameters

Correlation analysis was used to determine the effects of various process parameters on effluent quality, and thus on plant performance. The correlation coefficient between two sets of data (e.g., flow and effluent BOD_5), indicates the degree to which the variation in one variable is linearly related to the variation in another variable. Correlations were computed by facility for each process category to determine how strongly effluent concentration (i.e., daily values) was related to the plant operating factors given below:

- Flow
- Wastewater temperature
- Influent BOD_5
- Influent SS
- Primary effluent BOD_5
- Primary effluent SS
- BOD_5 loading
- SS loading
- Mixed liquor suspended solids (MLSS)
- Volatile MLSS
- Sludge age
- Hydraulic detention time

Both the Pearson correlation coefficient and Spearman rank order correlation coefficient were computed for all possible pairs of the above parameters. The Pearson correlation coefficient assumes that the underlying distribution of data is normal, while the Spearman correlation coefficient makes no such assumption. The results of these analyses can be summarized as follows: (1) the correlations of effluent data to other process variables were consistently weak and varied both in strength and sign from plant to plant, (2) correlations of BOD_5 effluent concentration with plant flow ranged, in most cases, from near zero to +0.4 and varied both in strength and sign from plant to plant, i.e., in some plants BOD_5 effluent concentration was inversely proportional to flow, (3) the correlations between SS effluent and flow were consistently lower than those of BOD_5, (4) correlations of effluent with temperature varied inversely and was strong in some cases and very weak in others and (5) correlations with operating parameters were generally weak even though theory predicts that significant relationships should exist. In conclusion, no single group of parameters was found to significantly account for effluent behavior for all plants. It is likely that the relationships were confounded or masked by other measured factors which need to be quantified first before the relationships can be determined.

Plant effluent quality was also correlated to plant size for each process category, using plant mean annual flow as the size measure and its mean annual BOD_5 and total SS (TSS) effluent concentration as the measure of quality. The results, presented in Table IV-7, indicate only a very weak relation (correlation close to zero) between process size and overall effluent performance, confirming the close agreement of effluent mean values and standard deviations between minor or major facilities. Thus the size of a plant has no statistical bearing on process performance, and effluent data for minor/major facilities can be grouped in later analyses.

C. DESCRIPTION OF PERFORMANCE CAPABILITIES

1. Averaging Periods

The characterization of the performance capabilities of facilities and process type classes was directed towards describing long-term average effluent quality, reliably achieved 30-day average effluent quality, and reliably achieved 7-day average effluent quality. The long-term average and 30-day average effluent quality values were investigated because these two factors are among the most important considerations in the design and performance of municipal wastewater treatment facilities. Since attainment of a 7-day average effluent value, as well as a 30-day average effluent value, is required under the existing secondary treatment definition, 7-day average effluent quality values were also investigated.

2. Expressions of Reliability

The reliability of a wastewater treatment facility in achieving a given effluent concentration for a given averaging period can be determined based on knowledge of process behavior and variations in facility performance. Because of variations in process performance, a treatment facility should be designed and operated to produce an average effluent concentration that is less than the discharge standard that facility must meet. Given an average effluent concentration and a factor that accurately expresses variability in the process, predictions can be made as to the percentage of time that a given facility can be expected to attain a given standard.

Similar analyses are also useful in treatment plant design. Designers must consider the degree of variability to be expected, as well as the average performance, if discharge requirements are to be met. Currently, most design techniques are based on steady state assumptions and average constituent values are used for design parameters. One method of accomodating process variability is to determine the expected effluent variation based on data from existing treatment plants. Linear regression models can be developed to predict the distribution percentiles of the BOD_5 and SS concentrations, based on the annual mean value of each parameter. Working backwards, designers can use the effluent concentration not to be exceeded, a prescribed percentage-of-the-time reliability factor, and then calculate the required average values. Using these computed average values as design criteria, traditional design methods can then be used to size the treatment units. If the design averages are achieved, treatment variability should be within the expected limits.

A commonly accepted level of reliability in wastewater engineering and design of wastewater treatment facilities is a 95th percentile for a 30-day average effluent value. Designing for a higher level, e.g., 99th percentile, or 100th percentile, involves increasingly higher capital and operating costs that are, in most cases, considered to less cost-effective in terms of pollutant removal achieved. Given an appropriate long-term average effluent value and an appropriate variability factor, the 95th percentile 30-day average value would reflect a value that the facility would be expected to attain at least 95 percent of the time, or 19 months out of every 20 months. In a typical 5-year period period, design value would predict that the 95th percentile effluent concentration would be exceeded only 3 times on a monthly average basis when design conditions are achieved. Throughout the useful life of the facility, especially when the facility was operated below design conditions, the frequency occurrence of exceedances would of course be less.

The 7-day average effluent concentration has typically not been used in the design of municipal wastewater treatment facilities that are needed to meet secondary treatment standards. Thus, there is no typical design reliability factor that is commonly in use. However, if the same estimated frequency occurrence of exceedance (3 times in 5 years) is used for a 7-day average, the appropriate expression of reliability would be 98.85 percent of the time, i.e. 3 weeks out of 5 years (260 weeks).

3. Alternative Approaches to Characterization of Variability

Given a certain level of reliability, a number of alternative approaches can be used to account for variability in facility performance. These approaches are discussed below.

(a) Actual data. As noted above, in the absence of a statistical distribution that represents a good fit of the data, actual data can be analyzed for the purposes of estimating plant capabilities. Expected 30-day average and 7-day average effluent values can be estimated from the actual data by calculating a set of 30-day moving averages and 7-day moving averages for each facility, and then determining a 95th percentile value for the complete set of 30-day moving averages, and a 99th percentile value for the complete set of 7-day moving averages. The estimated values will implicitly account for variability in plant performance; however, a separate variability factor will not be directly calculated in estimating the 30-day and 7-day average values.

(b) Normal Distributions. A normal approximation of the 95th percentile of the 30-day average effluent values and 99th percentile of the 7-day average effluent values can be statistically estimated in accordance with the Central Limit Theorem on the basis of the following expression:

$$m_x \text{ (VF), where } VF_N = (1 + (Z\ (o_{x_N}/m_x))).$$

m_x	Long-term average effluent value.
Z	For a 95th percentile approximation, $Z = 1.645$; for a 99th percentile approximation $Z = 2.33$.
N	The averaging period, e.g., $N = 30$ for 30-day average.
o_{x_N}	The standard deviation of the n-day average values from the overall facility mean (m_x).
o_{x_N}/m_x	Coefficient of variation for averaging period (N); also expressed as V_{x_N}.

The term, o_{xN}, can usually be expressed in terms of $o/N^{1/2}$, where o is the standard deviation from the distribution of the individual data points, if it can be assumed that the individual measurements on successive days are statistically independent. Thus, o_{x30}, the standard deviation of the 30-day averages from the overall facility mean, would be o/5.48, or the standard deviation of the daily data divided by the square-root of 30. However, as noted above, the data for effluent quality can be shown to be non-random. A correction for the exhibited non-randomness can be made by calculating the value of o_{xN} directly from the 30-day averages. As shown in Figures IV-1 through IV-4, the corrected standard deviations of the 30-day averages result in a considerably higher degree of variability for the 30-day average period than would be expected if the data were nonrandom.

Using the corrected standard deviations of the 30-day averages, coefficients of variation, and variability factors can then be calculated. While the goodness-of-fit tests indicate that a normal approximation is not representative of the distribution of the data (see above), the calculated values are useful as a check on the alternative statistical approaches. The following presents the range of coefficients of variation and variability factors derived from the analyses:

Category	Range of V_{x30}	Range of VF_{x30}
Trickling Filter (Rock)	0.1 - 0.6	1.16 - 1.99
Contact Stabilization	0.1 - 1.0	1.16 - 2.65
Others	0.2 - 0.7	1.33 - 2.15

V_{x30} = Coefficient of variation for 30-day moving averages, defined as o_{x30}/m_{x30}, where o_{x30} is the standard deviation of the 30-day moving averages from the mean of the 30-day moving averages (m_{x30}).

VF_{x30} is the variability factor in the expression, $m_{x30} * (VF_{x30})$, which estimates a 95th percentile, 30-day moving average, where $VF_{x30} = (1 + Z * (V_{x30}))$, and $Z = 1.645$ for a 95th percentile approximation.

(c) Lognormal Distributions.

Similar analyses to those performed for normal distributions are conducted by considering logarithmic transforms of the daily data, and adjusting the standard deviations of the 30-day averages to account for non-randomness. A more detailed discussion is presented in Section V of this document.

4. Compliance Frequency.

Compliance tables were generated for effluent BOD and TSS from each process category showing the percentage of plants in or below each given effluent concentration range with a given frequency or percentage of time. The standard range interval was 5 mg/L, with each interval identified by its midpoint. The frequency levels included were 50, 75, 90, 95, 99 and 100 percent of the time, as determined from the percentiles of the actual effluent data (30-day moving average) for individual plants. Finally, the cumulative percentage of plants in or below each concentration range was determined at each frequency (percent of time) level. Tables D-1 through D-12 in Appendix D of this document present the tables generated for given process type classes.

Also, compliance tables based on fitted probability distributions (the log-normal and two-parameter empirical) were compared to those based on actual data. Except for extreme values (100th and 99th percentiles), the tables based on the fitted probability distributions were in good agreement with each other and with those obtained from actual data. Because data were not random, the performance analysis was based on actual data.

TABLE IV-1

COMPARISON OF STANDARD ERRORS ($\sigma_{\bar{x}_{30}}$) OF 30 DAY CALENDAR AND MOVING AVERAGES

	FACILITY	No. of Obs.	σ_{Daily}	$\sigma_{\bar{x}_{30}}$ Calendar Avgs	$\sigma_{\bar{x}_{30}}$ Moving Avgs
Trickling Filter - Rock	303	751	5.3673	3.3559	3.2649
	56	724	20.5028	9.5598	9.7620
	309	696	7.8482	3.9474	4.0463
	651	628	17.5385	10.8746	9.9208
Trickling Filter - Plastic	162	913	9.3822	4.7624	5.0879
	114	716	7.8930	4.6957	5.3072
	435	711	12.5137	7.0841	6.9301
Activated Sludge - Conventional	322	761	13.4763	5.5944	5.4307
	319	759	28.8780	16.1267	15.3327
	312	756	7.6979	3.3019	3.6245
	321	748	4.6038	3.3718	3.4674
	150	730	6.3331	4.9169	4.8299
	35	725	21.8082	10.3315	9.0027
	320	714	5.4697	1.3994	2.5885
	161	709	34.8133	19.2893	18.0160
	315	707	7.4928	2.6582	2.7515
	109	706	18.6004	10.6212	9.8037
	141	701	8.1315	6.2313	6.0166
	159	699	12.0596	5.6166	5.6291
	128	697	12.5973	6.2545	5.9377
	139	697	2.3944	1.0202	1.5035
	227	695	6.8573	4.6101	4.8286
	107	692	4.0665	2.4101	2.3659
	225	688	20.2782	9.5020	8.1826
	324	682	4.4036	1.7275	1.7359
	433	677	8.3944	6.3182	6.9558
	432	661	13.8357	5.5275	6.1028
	40	650	5.8727	3.7171	4.0133
	160	637	9.6970	5.6185	5.8602
Activated Sludge - Contact Stabilization	145	731	12.0708	4.2731	4.2589
	177	723	7.7929	3.3854	3.0849
	425	696	15.6570	6.4179	9.0186
	415	670	28.7442	15.5215	15.2997
	129	644	8.1565	4.3333	4.8127
	662	623	29.9471	15.8685	14.5897
Rotating Biological Contactors	184	918	4.5867	3.1769	3.1339
	445	892	8.2183	6.4673	6.2589
	335	731	10.1901	7.7449	7.7749
	913	717	9.2498	5.3332	5.2050

TABLE IV-2

PERCENTAGE OF FACILITIES MEETING
A GIVEN BOD EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - ROCK - 30-DAY CALENDAR AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	98.44	98.44	98.44	100.00	100.00	100.00
85	96.88	96.88	98.44	98.44	100.00	100.00
80	95.31	95.31	98.44	98.44	100.00	100.00
75	92.19	92.19	92.19	96.88	100.00	100.00
70	92.19	92.19	92.19	95.31	100.00	100.00
65	87.50	87.50	89.06	95.31	98.44	100.00
60	81.25	81.25	84.38	92.19	98.44	100.00
55	78.13	78.13	78.13	90.63	96.88	100.00
50	67.19	67.19	71.88	84.38	93.75	96.88
45	64.06	64.06	64.06	75.00	92.19	95.31
40	48.44	48.44	53.13	65.63	84.38	93.75
35	42.19	42.19	43.75	54.69	71.88	92.19
30	23.44	23.44	29.69	42.19	60.94	76.56
25	10.94	10.94	12.50	20.31	37.50	57.81
20	3.13	3.13	3.13	3.13	21.88	39.06
15	1.56	1.56	1.56	1.56	6.25	20.31
10	1.56	1.56	1.56	1.56	1.56	7.81

PERCENTAGE OF FACILITIES MEETING
A GIVEN TSS EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - ROCK - 30-DAY CALENDAR AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	92.19	92.19	92.19	96.88	98.44	100.00
85	92.19	92.19	92.19	96.88	98.44	100.00
80	92.19	92.19	92.19	96.88	98.44	100.00
75	90.63	90.63	90.63	96.88	98.44	100.00
70	89.06	89.06	90.63	95.31	98.44	100.00
65	89.06	89.06	89.06	93.75	98.44	100.00
60	87.50	87.50	89.06	93.75	98.44	100.00
55	81.25	81.25	82.31	92.19	98.44	100.00
50	75.00	75.00	75.00	89.06	96.88	100.00
45	59.38	59.38	62.50	79.69	96.88	98.44
40	50.00	50.00	50.00	68.75	95.31	98.44
35	42.19	42.19	43.75	57.81	87.50	96.88
30	32.81	32.81	35.94	43.75	70.31	92.19
25	23.44	23.44	25.00	34.38	50.00	79.69
20	15.63	15.63	15.63	18.75	34.38	51.56
15	10.94	10.94	10.94	10.94	18.75	31.25
10	4.69	4.69	4.69	4.69	9.38	15.63

TABLE IV-3

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME TRICKLING FILTER - ROCK - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME					
	100%	99%	95%	90%	75%	50%
90	95.31	96.88	96.88	100.00	100.00	100.00
85	93.75	93.75	96.88	98.44	100.00	100.00
80	92.19	93.75	96.88	98.44	100.00	100.00
75	92.19	92.19	96.88	98.44	100.00	100.00
70	87.50	90.63	95.31	98.44	100.00	100.00
65	85.94	85.94	93.75	95.31	98.44	100.00
60	76.56	79.69	89.06	93.75	98.44	100.00
55	73.44	75.00	84.38	92.19	96.88	100.00
50	62.50	65.63	75.00	82.81	93.75	96.88
45	59.38	59.38	65.63	78.13	90.63	95.31
40	46.88	48.44	57.81	68.75	84.38	93.75
35	32.81	37.50	50.00	56.25	70.31	90.63
30	17.19	21.88	35.94	45.31	60.94	78.13
25	6.25	9.38	14.06	23.44	37.50	62.50
20	0.00	0.00	3.13	9.38	25.00	40.63
15	0.00	0.00	1.56	1.56	6.25	18.75
10	0.00	0.00	1.56	1.56	1.56	6.25

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME TRICKLING FILTER - ROCK - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME					
	100%	99%	95%	90%	75%	50%
90	92.19	92.19	96.88	100.00	100.00	100.00
85	92.19	92.19	96.88	100.00	100.00	100.00
80	90.63	90.63	96.88	98.44	100.00	100.00
75	89.06	89.06	95.31	98.44	100.00	100.00
70	84.38	87.50	95.31	96.88	100.00	100.00
65	81.25	84.38	93.75	96.88	100.00	100.00
60	81.25	84.38	92.19	96.88	100.00	100.00
55	76.56	79.69	87.50	96.88	100.00	100.00
50	70.31	73.44	81.25	93.75	100.00	100.00
45	56.25	57.81	71.88	87.50	98.44	100.00
40	48.44	50.00	59.38	75.00	96.88	100.00
35	39.06	42.19	51.56	64.06	87.50	98.44
30	28.13	29.69	42.19	51.56	70.31	93.75
25	18.75	20.31	28.13	34.38	51.56	75.00
20	6.25	9.38	14.06	21.88	31.25	50.00
15	4.69	4.69	6.25	7.81	15.63	31.25
10	3.13	3.13	3.13	4.69	7.81	14.06

TABLE IV-4

SUMMARY OF RESULTS - SECONDARY TREATMENT PLANTS

Range (Min-Max) Median

Process Category	Number of Plants	Effluent BOD (mg/l) Mean $\mu_{\bar{x}}$	Std. Dev. $\sigma_{\bar{x}}$	Coeff. of Var. $\nu_{\bar{x}}$	$\sigma_{\bar{x},30}$	$\sigma_{\bar{x},7}$	Effluent TSS (mg/l) Mean $\mu_{\bar{x}}$	Std. Dev. $\sigma_{\bar{x}}$	Coeff. of Var. $\nu_{\bar{x}}$	$\sigma_{\bar{x},30}$	$\sigma_{\bar{x},7}$	Flow (mgd) Mean $\mu_{\bar{x}}$	Std. Dev. $\sigma_{\bar{x}}$	Coeff. of Var. $\nu_{\bar{x}}$
Trickling Filter - Rock	64	8.49-57.58 26.03	2.41-30.72 10.06	0.11-1.02 0.40	1.71-14.58 5.88	2.02-23.27 7.67	9.18-101.3 25.25	3.24-121.1 10.77	0.11-1.65 0.50	2.12-27.00 6.28	2.91-51.09 7.46	0.03-9.42 0.65	0.004-2.36 0.23	0.06-0.97 0.27
Trickling Filter -Plastic	17	7.18-55.41 18.98	3.62-27.45 9.38	0.15-0.90 0.49	3.04-13.73 5.48	3.40-19.46 7.01	5.76-42.83 19.36	5.40-19.11 8.29	0.27-1.40 0.65	2.36-12.72 5.11	3.38-14.28 7.05	0.13-8.68 0.92	0.07-2.36 0.40	0.16-0.88 0.38
Activated Sludge -Conventional	66	3.92-41.49 14.79	2.39-34.82 8.18	0.19-1.99 0.66	1.50-21.29 5.08	1.57-27.39 6.65	5.06-52.25 14.30	2.71-78.20 12.33	0.18-2.21 0.83	1.22-39.03 6.89	1.60-54.31 8.75	0.05-82.7 1.87	0.02-18.79 0.53	0.04-1.04 0.24
Activated Sludge -Contact Stab.	57	3.82-45.43 12.63	1.05-43.66 8.16	0.07-1.73 0.60	1.00-32.44 5.54	0.98-38.95 6.88	3.66-46.[illegible]5 13.80	1.52-75.14 9.30	0.23-2.02 0.71	1.67-39.53 6.24	2.22-50.12 8.[illegible]	0.002-56.23 0.36	0.002-16.22 0.13	0.06-1.35 0.34
Activated Sludge -Extended Aer.	28	2.67-27.89 7.20	0.96-19.81 4.60	0.21-2.03 0.71	0.67-17.15 3.03	0.95-19.6 3.89	2.46-33.35 9.78	0.46-38.10 7.11	0.18-1.95 0.66	0.19-35.45 3.42	0.25-36.97 4.77	0.01-5.80 0.10	0.006-0.89 0.06	0.11-1.32 0.34
R.B.C.	27	4.79-32.27 16.99	4.49-47.43 10.19	0.29-1.47 0.58	2.75-20.27 6.26	3.39-31.60 7.89	6.65-22.86 15.15	4.47-22.11 8.46	0.39-1.27 0.69	1.70-15.26 4.50	3.22-17.17 6.40	0.06-31.60 0.71	0.03-1.96 0.23	0.12-1.19 0.31
Oxidation Ditch	28	2.93-29.20 8.40	1.13-17.95 5.88	0.14-1.59 0.57	1.01-17.22 3.98	1.23-17.88 5.58	3.77-31.55 12.26	1.88-47.65 8.61	0.21-1.86 0.68	1.46-222.12 5.98	1.92-389.8 9.88	0.01-6.33 0.18	0.004-1.15 0.07	0.09-1.16 0.31
Stabilization Pond	37	8.59-70.96 22.71	5.79-46.5 9.78	0.25-1.08 0.51	4.59-38.70 8.04	5.38-46.39 8.63	12.60-133.00 39.51	5.29-156.97 22.56	0.30-1.18 0.63	3.18-128.17 17.10	4.45-135.98 19.44	0.03-2.73 0.31	0.000-1.57 0.09	0.00-0.83 0.31

$\mu_{\bar{x}}$ = Overall facility means

$\sigma_{\bar{x}}$ = Overall facility standard deviations

$\nu_{\bar{x}}$ = Overall facility coefficients of variation

$\sigma_{\bar{x},30}$ = Overall facility standard deviations of 30-day moving averages

$\sigma_{\bar{x},7}$ = Overall facility standard deviation of 7-day moving averages

TABLE IV-5

RUNS TEST RESULTS FOR TRICKLING FILTER - ROCK MEDIA FACILITIES

Facility No.	BOD_5		SS	
	Z	Prob.	Z	Prob.
051	-10.70	0	- 1.96	.05
052	- 9.69	0	- 7.08	0
053	- 6.42	0	- 2.67	0
054	- 9.10	0	- 5.66	0
055	- 8.04	0	- 8.26	0
056	- 8.93	0	-10.35	0
303	-14.35	0	-18.73	0
304	- 9.94	0	- 6.42	0
309	-13.94	0	-13.60	0
345	- 5.86	0	-10.06	0
418	- 4.07	0	- 5.47	0
524	-11.63	0	-12.24	0
653	- 5.70	0	-11.80	0
655	- 7.79	0	- 7.58	0
665	- 5.68	0	-14.68	0
963	- 6.96	0	- 5.79	0
971	- 8.10	0	- 8.74	0

TABLE IV-5

RUNS TEST RESULTS FOR TRICKLING FILTER - ROCK MEDIA FACILITIES

Facility No.	BOD_5		SS	
	Z	Prob.	Z	Prob.
051	-10.70	0	- 1.96	.05
052	- 9.69	0	- 7.08	0
053	- 6.42	0	- 2.67	0
054	- 9.10	0	- 5.66	0
055	- 8.04	0	- 8.26	0
056	- 8.93	0	-10.35	0
303	-14.35	0	-18.73	0
304	- 9.94	0	- 6.42	0
309	-13.94	0	-13.60	0
345	- 5.86	0	-10.06	0
418	- 4.07	0	- 5.47	0
524	-11.63	0	-12.24	0
653	- 5.70	0	-11.80	0
655	- 7.79	0	- 7.58	0
665	- 5.68	0	-14.68	0
963	- 6.96	0	- 5.79	0
971	- 8.10	0	- 8.74	0

TABLE IV-6

SERIAL CORRELATION COEFFICIENTS FOR SELECT TRICKLING FILTER - ROCK MEDIA FACILITIES

Facility Number	BOD_5	Significance	SS	Significance
50	0.59	0.01	0.32	0.01
56	0.36	0.01	0.47	0.01
301	0.85	0.01	0.32	0.01
302	0.50	0.01	0.37	0.01
303	0.56	0.01	0.81	0.01
522	0.77	0.01	0.55	0.01

TABLE IV-7

PLANT SIZE VS EFFLUENT QUALITY PEARSON CORRELATION COEFFICIENTS FOR MEAN ANNUAL FLOW VS MEAN ANNUAL BOD_5 AND TSS EFFLUENT

Process Category		Mean BOD_5	Mean TSS
Trickling Filter - Rock Media	r	-0.1236	-0.0358
	No. of Obs	138	133
Tricling Filter - Plastic Media	r	-0.0784	-0.1085
	No. of Obs	36	36
Activated Sludge - Conventional	r	-0.0240	-0.0911
	No. of Obs	148	148
Activated Sludge - Contact Stabilization	r	-0.2895	-0.3006
	No. of Obs	128	128
Activated Sludge - Extended Aeration	r	-0.2225	-0.1608
	No. of Obs	61	59
R.B.C.	r	-0.1351	-0.0307
	No. of Obs	59	59
Oxidation Ditch	r	-0.1787	0.3868
	No. of Obs	57	57
Stabilization Pond	r	-0.2222	0.2224
	No. of Obs	61	61

FIGURE IV-1

STANDARD DEVIATIONS OF DAILY EFFLUENT BOD VERSUS STANDARD ERROR OF 30-DAY MEANS
FOR TRICKLING FILTER PLANTS

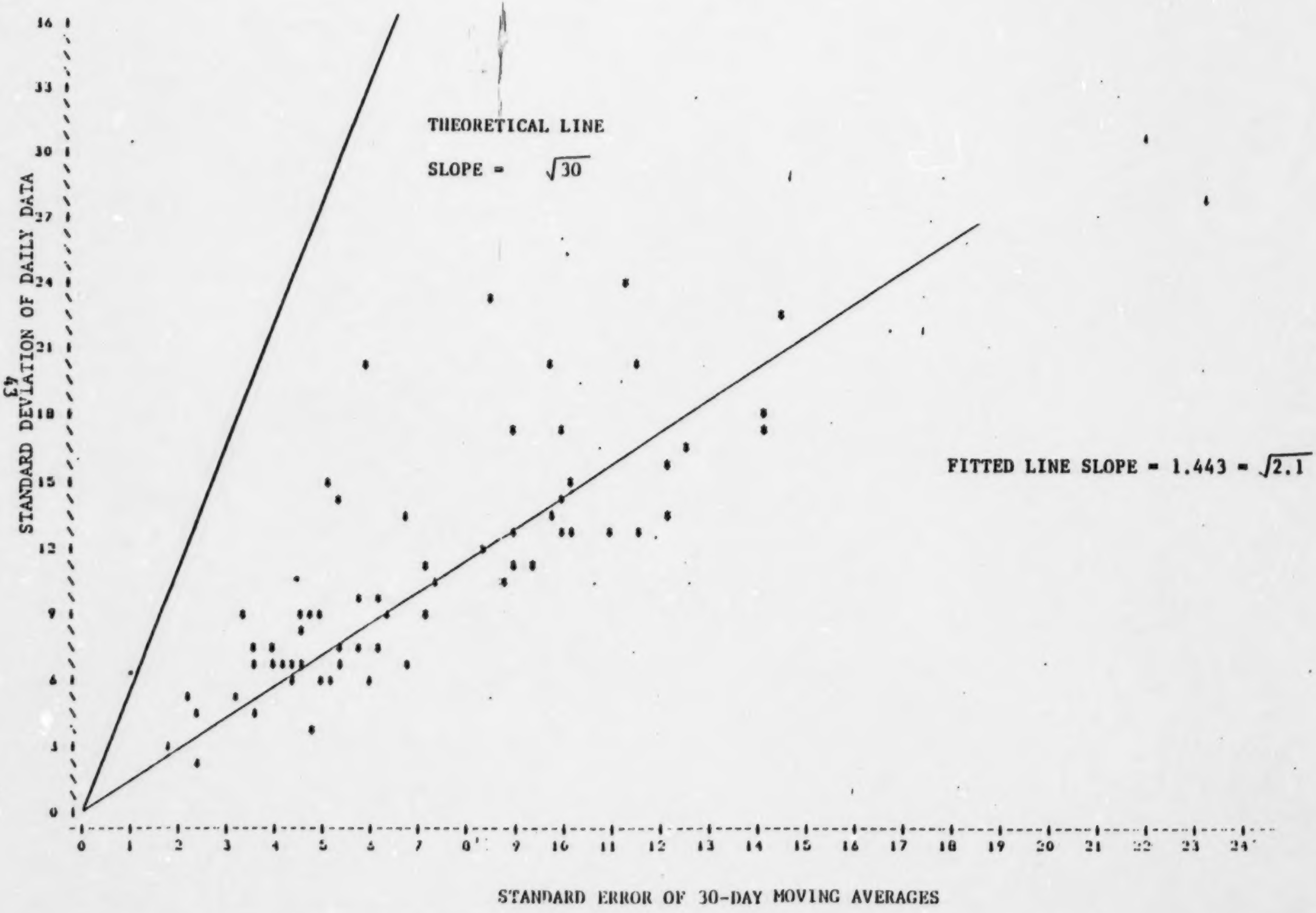


FIGURE IV-2

STANDARD DEVIATION OF DAILY EFFLUENT BOD VERSUS STANDARD ERROR OF 30-DAY MEANS FOR ACTIVATED SLUDGE - CONVENTIONAL PLANTS

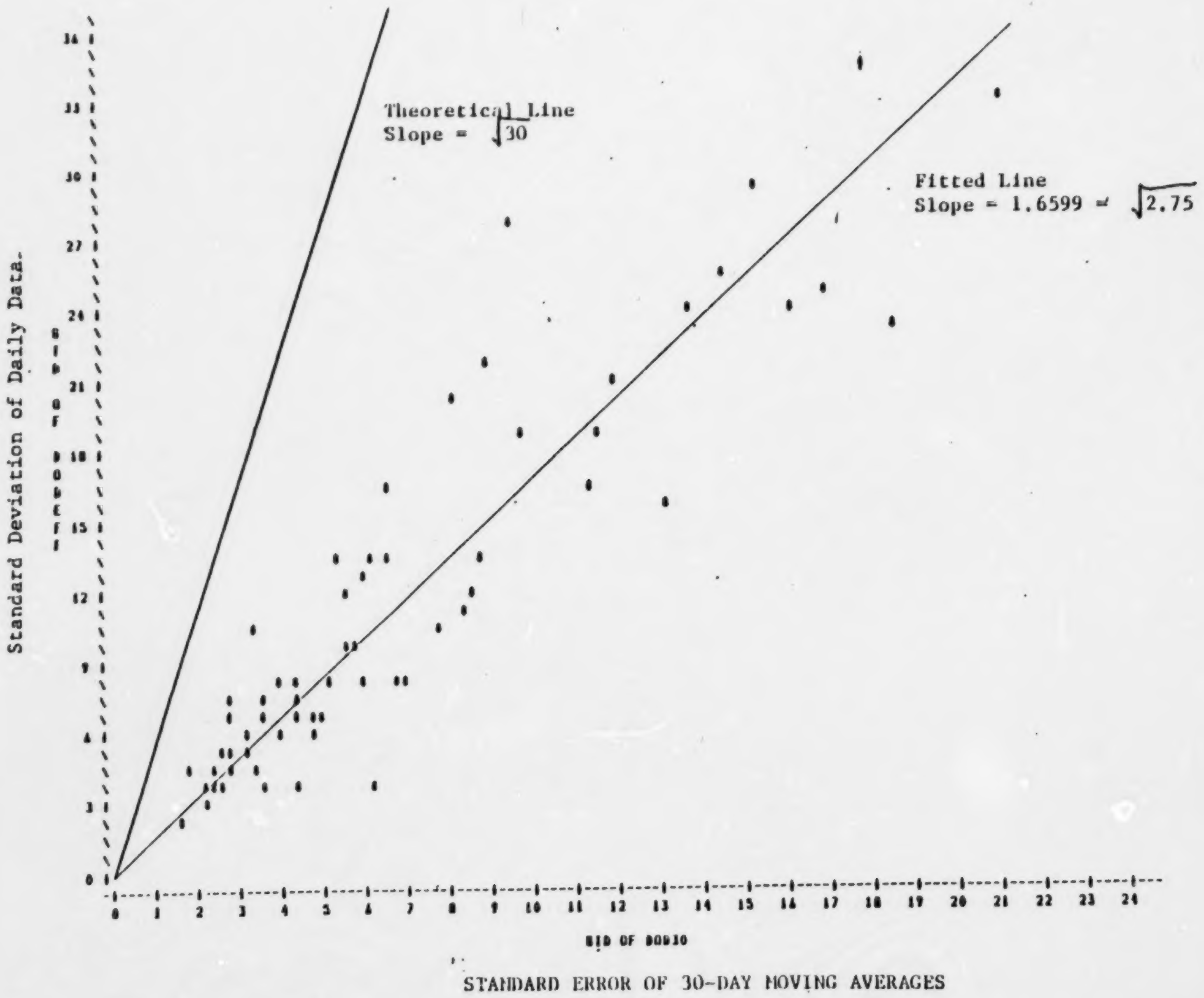


FIGURE IV-3

STANDARD DEVIATION OF DAILY EFFLUENT BOD VERSUS STANDARD ERROR OF 30-DAY MEANS
FOR OXIDATION DITCH PLANTS

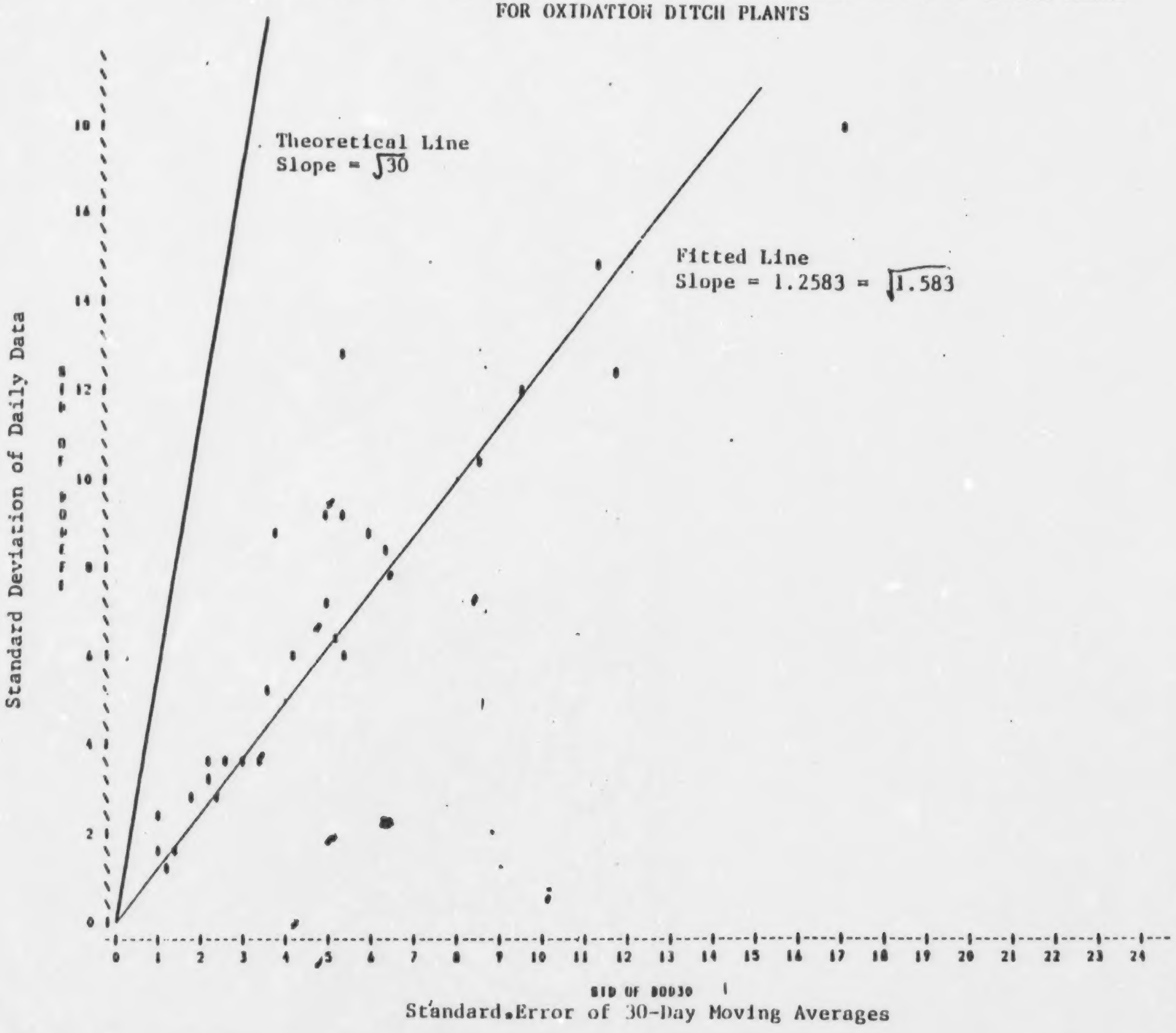
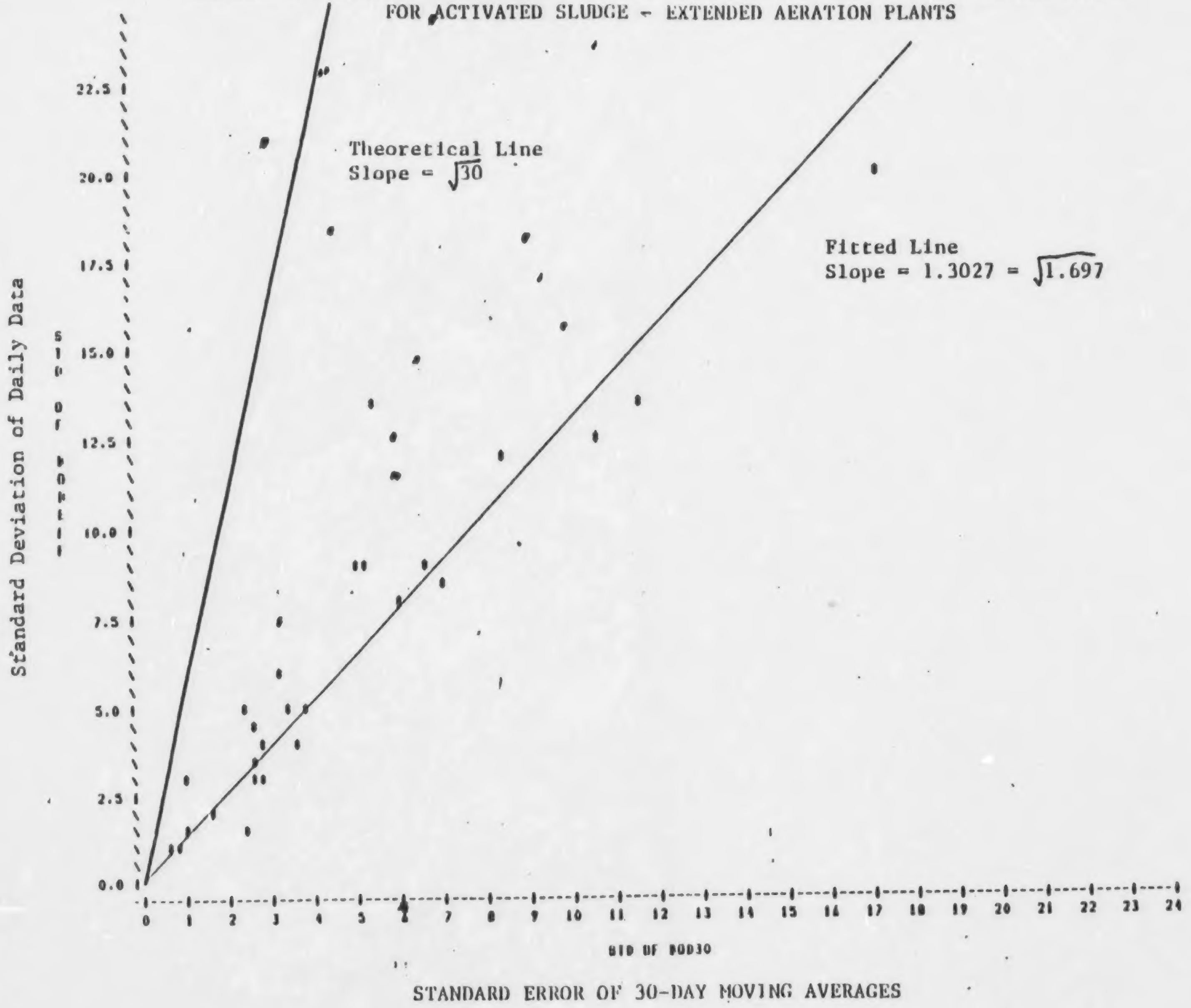


FIGURE IV-4

STANDARD DEVIATION OF DAILY EFFLUENT BOD VERSUS STANDARD ERROR OF 30-DAY MEANS FOR ACTIVATED SLUDGE - EXTENDED AERATION PLANTS



SECTION V

CLASSIFICATION OF BIOLOGICAL TREATMENT FACILITIES

A. SUMMARY

The legislative history for Section 304(d)(4) of the Act suggests that certain treatment facilities employing biological treatment processes may be deemed equivalent to secondary treatment, and their use sanctioned, in spite of the fact that their current level of effluent quality may exceed secondary treatment standards. The Agency has interpreted Section 304(d)(4) of the Act as requiring classification of certain biological treatment processes as either secondary treatment or as treatment equivalent to secondary treatment, based on the general performance of a given treatment process type with respect to secondary treatment standards. The legislative history indicates that inability to meet current requirements is a condition for eligibility for treatment equivalent to secondary treatment. However, the legislative history does not suggest that "non-compliance" alone is sufficient grounds for modification of a permit. The legislative history directs the Administrator to consider processes that provide significant reductions of BOD_5 and SS, and consider their variations in performance and design under various conditions. The Agency has interpreted the legislative history as requiring a showing that a process type cannot be expected to consistently achieve secondary treatment, and allowing NPDES permit adjustments for facilities using such processes, where the given facility cannot consistently meet secondary treatment.

The following section describes the technical considerations that EPA made in assessing the performance of given process types. For the purposes of the technical evaluation, the following classes of biological treatment facilities were examined:

- Trickling Filter, Rock Media, Year Round Data
  Trickling Filter, Rock Media, Winter Data Only
  Trickling Filter, Rock Media, Summer Data Only
- Trickling Filter, Plastic Media, Year Round Data
  Trickling Filter, Plastic Media, Winter Data Only
  Trickling Filter, Plastic Media, Summer Data Only
- Activated Sludge, Conventional, All Facilities
  Activated Sludge, Conventional, Pre-P.L. 92-500 Facilities
  Activated Sludge, Conventional, Post-P.L. 92-500 Facilities
- Activated Sludge, Contact Stabilization
- Activated Sludge, Extended Aeration
- Rotating Biological Contactor
- Oxidation Ditch
- Waste Stabilization Pond

B. DEFINITION OF PROCESS TYPE CRITERIA FOR FACILITIES ELIGIBLE FOR TREATMENT EQUIVALENT TO SECONDARY TREATMENT

1. Methodology

The following section discusses the design of the study used by the Agency to characterize process type classes as secondary treatment or treatment equivalent to secondary treatment. Using estimates of the 95th percentile from the empirical data and approximations from statistical distributions of the data (lognormal and normal distributions), the performance level of a given process type class was characterized in terms of a typical or central value. Such values were obtained by determining the median 95th percentile 30-day average, an average of the 95th percentile 30-day averages weighted by number of observations for each facility, and an unweighted average of the 95th percentile 30-day averages. The goal of the analysis was to determine whether a given biological treatment process could be expected to reliably achieve current technology-based requirements.

(a) Averaging Periods. For the purposes of characterizing the performance capabilities of process type classes identified for technical evaluation, the Agency considered both the 30-day average and 7-day averages for BOD_5 and SS for a given facility, and the ability of the facility to meet current secondary treatment standards. Analyses of the data indicated that the 7-day values (99th percentile) were greater than the 30-day average values (95th percentile) by a factor within a range of 1.2 to 1.8; however, a substantial number of the facilities exhibited a relationship of less than 1.5. Since the existing secondary treatment regulations reflect a 1.5 factor (7-day:30-day::45 mg/L:30mg/L), the data indicated that the 7-day average value was not limiting. Therefore, the analyses focused only on the 30-day average values.

(b) Analyses Based on Empirical Data. As noted in Section IV of this document, the actual data were found to be more representative of plant performance than predicted values using statistical parameters describing the distribution of the data. As discussed earlier, the 30-day average effluent values for each facility were computed on a moving average basis. For each facility, a 95th percentile value was estimated from the complete set of 30-day moving averages for that facility. Summary presentations of these analyses can be found in the compliance frequency tables found in Appendix D of this document (Tables D-1 through D-12). Actual facility-by-facility data summaries for the trickling filter, oxidation ditch, and waste stabilization pond process type classes are presented in Appendix E (Tables E-1 through E-8).

(c) Analyses Based on Lognormal Distributions Although the lognormal distribution was not found to be representative of the data for all facilities, analyses were conducted assuming a lognormal distribution of the data for the rock media trickling filter, conventional activated sludge, and waste stabilization pond categories. Parameters that characterize the lognormal distribution of the data for each facility were estimated. These parameters were the mean and the standard deviation of the 30-day averages as deriving from the logarithms of the original data.

The maximum liklihood estimates of these parameters are given by the formulae:

$$u_{30} = \mathop{E}_{i=1}^{N} \ln (X_i)/N \qquad (1)$$

$$o_{x30} = (\mathop{E}_{i=1}^{N} (\ln(X_i) - u_{30})^2/N)^{1/2} \qquad (2)$$

where X_i is the i-th BOD_5 or SS 30-day average value at a plant and N is the total number of 30-day averages.

By knowing u and o_{x30}, it is possible to compute the mean, m_x, and standard deviation, s, of the distribution proper:

$$m_x = \exp (u_{30} + .5\ o^2) \qquad (3)$$

$$s_{x30} = m_x (\exp (\ o_{x30}{}^2) - 1)^{1/2} \qquad (4)$$

For each facility the estimated mean and standard deviation of the 30-day averages were used to predict a 95th percentile effluent value for BOD_5 and SS as follows:

$$E_{95} = m_x (1 + (Z (s_{x30}/m_x) \qquad (5)$$

where E_{95} is equal to the 30-day average effluent value that is expected to be achieved 95 percent of the time, and where $Z = 1.645$.

The results of these analyses are presented in Appendix E of this document (Tables E-9 through E-14).

(d) Normal Distribution. Although a normal distribution was found to be not representative of the effluent data for most studied facilities (see Section IV of this document), further analyses were conducted to determine whether a normal approximation yielded equivalent values. The central tendency of various process type classes was determined by using the median value of the overall facility means for a given process type class and the median value for the overall facility standard deviation of the 30-day moving averages (see Table IV-4). The performance capabilities were estimated for each process class in terms of the following:

$$P_{med} = u_{xmed} + (1.645\ o_{x30med}) \qquad (6)$$

where P_{med} is the expected performance level for a process type class, based on the median values for the overall facility means (u_x), the standard deviation of the 30-day moving averages (o_{x30med}), and an approximation of the 95th percentile in a normal distribution using a Z-factor of 1.645.

The results of this analysis are presented in Appendix E (Table E-15).

2. Conclusions

As reflected in the results presented in the compliance frequency tables (Appendix D, Tables D-1 through D-12), and summary tables (Appendix E), the analysis of effluent data for the rock media trickling filter category and waste stabilization pond category indicates that those two categories experience the greatest difficulty in achieving secondary treatment requirements. The trickling filter, plastic media category can be characterized as marginal in terms of providing a level of treatment that would consistently meet secondary treatment standards, especially during cold weather periods. Therefore, the use of one of these process type classes would be indicated as a criterion for treatment equivalent to secondary treatment.

For the other process type classes, the analyses indicated that secondary treatment requirements were achievable with a high degree of reliability by most facilities within the process category; however, within each of these "secondary treatment" process type classes, there were instances of facilities that exceeded secondary treatment standards. The number of the observed facility exceedances for the process types classified as "secondary treatment" ranged from 18 to 40 percent of the facilities, depending on process type and pollutant parameter. However, given the long-term average effluent concentrations for these categories, which were typically less than 15 mg/L for both BOD_5 and SS, and 30-day average variability factors (see Section IV.C.3. of this document) that were typically below 2.0, the Agency has determined that secondary treatment standards are attainable through the use of the activated sludge, oxidation ditch, and rotating biological contactor process types.

SECTION VI

MINIMUM LEVEL OF EFFLUENT QUALITY ATTAINABLE

A. SUMMARY

This section summarizes the technical evaluations of performance data that were carried out to define the minimum level of effluent quality attainable by the class of facilities that meet the following criteria:

(1) the facilities provide a significant reduction of BOD_5 and SS,
(2) the facilities use either a trickling filter or waste stabilization pond as the principal treatment process, and
(3) the facilities cannot consistently achieve (at least 95 percent of the time or better) an effluent quality of 30 mg/L BOD_5 and SS on a 30-day average basis.

B. DESCRIPTION OF DATA

The trickling filter and waste stabilization pond process type classes were examined to determine those facilities that could not achieve 30 mg/L BOD_5 and SS on a 30-day average basis, using a 95th percentile value. As described in Section II of this document, in order to maintain an adequate sample size for the plastic media trickling filter category, analyses included facilities that used chemical additional as an adjunct to the trickling filter. In screening the plastic media trickling filter category in terms of the criteria described in Section VI.A. above, it was further determined that the resulting sample of plastic media trickling filters was too small to stand by itself and still support valid conclusions. Therefore, for purposes of the analyses described in this section, the plastic media and rock media trickling filters were grouped together.

For the waste stabilization pond process, analyses were conducted using (1) a sample composed of ponds without additional processes and outliers, and (2) a sample that included selected facilities using additional processes or selected facilities that were previously designated as outliers. The basis for identification of certain pond facilities as "outliers" is described in Task Report of the contractor's summary reports, Contract No. 68-01-6755, Work Assignment 2, Action Number 2. Unselected outlier facilities are designated in Tables E-7 and E-8 in Appendix E of this document.

C. ANALYSES USED IN DETERMINING MINIMUM ATTAINABLE LEVELS OF EFFLUENT QUALITY

1. Actual Data

As with the analyses described in Section V of this document, actual data for selected facilities were used to estimate a 95th percentile 30-day moving average value. For the category of facilities eligible for treatment equivalent to secondary treatment (see criteria in Section VI. A), the typical or central value of the category was determined by calculating average values for the class, average values for the class weighted by the number of observations for each facility, and the median value of all facilities in the class. Summary tables (F-1 through F-16) presented the results of those analyses are found in Appendix F of this document. For the regulatory purposes, the median BOD$_5$ and SS effluent values were chosen as expressing a representative level of effluent quality for the class. The average values and weighted average values were essentially the same, or slightly higher, for most categories, and for the purposes of this analysis could be considered as methodologies equivalent to the use of the median.

The various analyses provided 30-day average BOD$_5$ and SS values of 40 to 45 mg/L.

2. Long-term Averages and Variability Factors

As described in Section IV of this document, long-term averages and 30-day average variability factors were calaculated for various process types. For tricklings, the long-term average BOD$_5$ and SS values for the category of facilities eligible ranged from approximately 20 mg/L to 40 mg/L (range defined by 10th and 90th percentiles of all facilities sampled) with average or median values of approximately 28 to 30 mg/L (see Tables F-1 and F-3, Appendix F). As noted in Section IV, the 30-day average variability factors for trickling filters ranged from 1.16 to 1.99, with 1.5 as the typical value. For waste stabilization ponds, the long-term average BOD$_5$ values for the category of facilities eligible ranged from 17 mg/L to 44 mg/L (range defined by 10th and 90th percentiles of all facilities sampled) with average or median values of approximately 20 to 25 mg/L (see Table F-13, Appendix F). The 30-day average variability factors for BOD$_5$ for ponds ranged from 1.16 to 2.65, with a factor of 1.8 as a typical value.

Based on the typical long-term averages and 30-day variability factors, a value of 40 to 45 mg/L would be expected for BOD$_5$ and SS.

3. Lognormal Distribution

As a check on the analysis performed with actual data, analyses based on an assumed lognormal distribution of the data (see Section V.B.1.c of this document) were also conducted for those rock media trickling filter and waste stabilization pond facilities that met the criteria specified in Section VI.A of this document. As with the actual data, average values, weighted average values, and median values for the estimated 95th percentile 30-day average were calculated for the overall category. The results of these analyses are presented in Tables F-17 through F-20 of Appendix F to this document.

Based on the lognormal analyses, the average and median values for the 30-day average BOD_5 and SS for trickling filters and BOD_5 for waste stabilization ponds were between 40 and 45 mg/L. The SS value for ponds was estimated to be approximately 95 mg/L at the median, and from 135 to 180 mg/L using unweighted and weighted averages, respectively. When analyses were conducted excluding facilities in which the coeficient of variation exceeded 1.0, the SS values for ponds were estimated at 66 mg/L (median 30-day), and approximately 69 mg/L for both the weighted and unweighted 30-day averages.

3. Conclusions

Using the variety of approaches to the data described above, the minimum level of effluent quality attainable for the category of facilities eligible for treatment equivalent to secondary treatment can be characterized in terms of BOD_5 30-day average values of approximately 45 mg/L for both trickling filters and waste stabilization ponds, and 30-day average SS values of approximately 45 mg/L for trickling filters. For waste stabilization ponds, the 30-day average SS values exhibited a high degree of variability. An appropriate characterization would describe 30-day average SS values for ponds as typically greater than 65 mg/L at a 95th percentile frequency.

For regulatory purposes, the following were determined to be appropriate:

- a 30-day average BOD_5 value of 45 mg/L for both trickling filters and waste stabilization ponds,
- a 30-day average SS value of 45 mg/L for trickling filters,
- the existing regulatory scheme specified in 40 CFR 133.103(c) for SS values for waste stabilization ponds.

4. Verification

The Agency reviewed other studies on the performance of trickling filters to verify the conclusions reached above. The EPA Region VII Trickling Filter Performance Analysis (Ref. 20) examined the performance of 72 trickling filter facilities in the States of Kansas, Iowa, and Nebraska. Based on lognormal representations of the data, the Region VII analysis would suggest that 30-day average BOD_5 and SS effluent limits of 45 mg/L would be consistently achieved by 75 to 100 percent of the trickling filter facilities in those States on a year-round basis.

A report by the USEPA Municipal Environmental Research Laboratory (MERL), entitled "Performance of Trickling Filter Plants: Reliability, Stability and Variability" (Ref. 5), would suggest that a long-term average BOD_5 and SS effluent value of 30 mg/L and a 1.5 30-day average variability factor are characteristic values expressing typical performance by trickling filters that cannot consistently achieve secondary treatment requirements.

D. DISCUSSION OF VARIABILITY FOR 7-DAY AVERAGES

For the category of eligible facilities, *i.e.*, trickling filters and waste stabilization ponds that cannot consistently achieve 30 mg/L BOD_5 and SS (see criteria in Section VI.A. of this document), the relationship of the 95th percentile 30-day average values to the 99th percentile 7-day average values was examined. Table F-21 presents the ratios of 7-day averages to 30-day averages for the trickling filter and pond categories, based on BOD_5 and SS effluent data for the median 30-day (95th percentile) and median 7-day (99th percentile) values, the average of the 30-day (95th percentile) and the average of the 7-day (99th percentile) values, and the weighted average of the 30-day (95th percentile) and the weighted average of the 7-day (99th percentile) values.

For the parameters, processes, and facilities examined, the analyses support a 7-day to 30-day ratio of 1.3 to 1.7. For regulatory purposes, the Agency used a factor of 1.5 to express the 7-day to 30-day ratio, which is consistent with the current secondary treatment regulation.

E. PERCENT REMOVAL

The legislative history notes that trickling filter and pond facilities achieve significant reductions of BOD_5 and SS, but may not be capable of achieving the secondary treatment standard of 85 percent removal consistently. The fact sheets referenced in Section III of this document (see Appendix C of this document) indicate that a facility using a trickling filter or pond as a biological treatment process can be expected to remove between 60 and 90 percent of BOD_5, based on the raw wastewater influent to the plant. As indicated in Table VI-1, engineering practice for trickling filters before the Clean Water Act (circa 1960) suggested a design criterion of 65 to 90 percent removal for BOD_5. It is also noted that the legislative history for the 1972 Clean Water Act described primary treatment as removing from 30 to 50 percent of organic matter, i.e., BOD_5, while secondary treatment was described as removing from 50 to 90 percent removal of BOD_5 [S. Rep. 92-414, 92d Cong., 2d Sess. 6 (1972)].

Based on these considerations of removal efficiency, and the intent of the Act to encourage the use of trickling filters and ponds, the Agency believes that 65 percent removal on a 30-day average basis for BOD_5 is an appropriate minimum level of pollutant removal efficiencies to be expected from trickling filters and waste stabilization ponds. A 65 percent removal criterion is also considered appropriate for SS for trickling filters; however, for waste stabilization ponds, the provisions of the existing secondary treatment regulation with respect to SS values achievable by ponds are considered appropriate, *i.e.*, no percent removal value is specified.

TABLE VI-1

EFFICIENCIES OF SEWAGE TREATMENT METHODS

Type of treatment	Per cent reduction		
	Suspended matter	B.O.D.	Bacteria
Fine screens	5-20		10-20
Plain sedimentation	35-65	25-40	50-60
Chemical precipitation	75-90	60-85	70-90
Low-rate trickling filter, including presedimentation and final sedimentation	70-90+	75-90	90+
High-rate trickling filter, including presedimentation and final sedimentation	70-90	65-95	70-95
Conventional activated sludge, including presedimentation and final sedimentation	80-95	80-95	90-95+
High-rate activated sludge, including presedimentation and final sedimentation	70-90	70-95	80-95
Contact aeration, including presedimentation and final sedimentation	80-95	80-95	90-95+
Intermittent sand filtration, including presedimentation	90-95	85-95	95+
Chlorination:			
Settled sewage		[1]	90-95
Biologically treated sewage		[1]	98-99

[1] Reduction is dependent upon dosage.

SOURCE: Ernest W. Steel, Water Supply and Sewerage (New York: McGraw-Hill Book Co., 1960)

SECTION VII

GUIDANCE FOR IMPLEMENTING ALTERNATIVE STATE REQUIREMENTS (ASRs)

A. INTRODUCTION

The legislative history (see Section II and Appendix B of this document) directed the Administrator to:

> take into account not only pollutant removal efficiencies, but also differing geographical/climatic conditions which affect treatment plant performance. The Administrator should also address the seasonal and geographical variability of biological treatment plant performance in the regulations issued to carry out this section. [S. Rep. No. 97-204, 97th Cong., 1st Sess. 18 (1981)]

Where wide variations in the performance of a treatment process occur due to such conditions, the establishment of a single performance standard will result in either: (1) an overly stringent value that will be difficult for facilities operating under the most adverse conditions to attain, or (2) an overly lenient value that would implicitly sanction less than optimum performance by facilities operating under the most favorable conditions. In such cases, procedures for adjusting individual facility values from a nationally established standard are warranted, if effluent limitations are to reflect accurately the variety of local conditions (cf. recommendations of the House Subcommittee on Investigations and Oversight, [H.R. Rep. No. 97-30, 97th Cong., 1st Sess. 73 (1981)], Appendix B of this document)

As described in Section VI of this document, the minimum level of effluent quality attainable by eligible trickling filters and waste stabilization ponds is based on single values characterizing typical performance on a nation-wide basis. Although the national scope of the sampled facilities and the analysis encompasses a wide range of geographical, seasonal and climatic conditions, variations in such factors at the local level are likely to result in disparate performance capabilities of facilities. The Agency addresses performance variability by: (1) allowing the establishment of alternative state requirements where local conditions affect the ability of eligible facilities to meet the proposed national standard, and (2) requiring that permit effluent limitations for individual facilities be based on the past performance of a facility, where the facility has achieved a level of effluent quality more stringent than the national standard.

This section describes criteria for establishing alternative state requirements (ASRs), while guidance for implementing individual permit adjustments is discussed in Section VIII of this document.

B. METHODOLOGIES CONSIDERED BY EPA FOR DEVELOPING ASRs

The waste stabilization pond permit adjustment for SS concentrations (existing § 133.103(c)) provides a precedent for allowing States to participate in setting alternative effluent requirements by assessing the performance of local treatment works. In order to implement a similar process in an expedited manner, a Regional Administrator or State determines the effluent concentrations consistently achieved by TF and WSP facilities in accordance with criteria set forth in the final rule (see Section VII. C. below). EPA retains responsibility for approving any alternative requirements suggested by a State, and may veto any non-conforming permit (40 CFR (123.44(c)).

Since the implementation of the ASR provision would involves application of the regulatory criteria set forth in § 133.105(d) during the NPDES permit process, EPA will not be proposing or promulgating the approved alternative effluent requirements. However, the permitting authority is required to provide notice and opportunity for public comment on the ASR, and the Agency intends to publish the values in the Federal Register as was done for ponds suspended solids [43 FR 55279].

C. CRITERIA FOR ESTABLISHING ASRs

As an alternative to the national values established for BOD_5 and SS concentrations, individual States may recommend alternative effluent requirements that will more accurately reflect the performance of trickling filter and waste stabilization pond facilities within their State than the national limits. In order to establish an ASR, a State must demonstrate that certain criteria will be met. The criteria, which would result in a State using a methodology equivalent to that described in Section VI of this document, are as follows:

1. The analysis includes only those facilities that are eligible for consideration under treatment equivalent to secondary treatment, i.e., the BOD_5 and SS effluent concentrations consistently achieved through proper operation and maintenance (§ 133.101(f)) of the treatment works indicate that the current standards of secondary treatment cannot be consistently achieved, a trickling filter or waste stabilization pond is used as the principal process, and the treatment works provide significant biological treatment of municipal wastewater.

2. For each facility and given pollutant parameter, the effluent quality is characterized in terms of the following: (a) the 95th percentile value for the 30-day average effluent quality achieved by a treatment works in a period of at least two years, excluding values attributable to upsets, bypasses, operational errors, or other unusual conditions, and (b) a 7-day average value equal to 1.5 times the 30-day value.

3. The ASR is based on the level of effluent quality achieved by the median (50th percentile) facility in the sample.

A representative sample of the complete universe of eligible facilities within a State or appropriate contiguous geographical area may be used, where appropriate, to facilitate the analysis. Issues involved with the use of a sample are discussed in Section VII. C. below. Section II of this document describes general procedures that may be followed in identifying and screening facilities for analysis.

In all cases, the resulting data base must be analyzed in accordance with criteria (2) and (3) as described above. Alternative approaches for characterizing the 95th percentile 30-day average effluent quality are described in Sections V and VI of this document. The minimum level of effluent quality for the ASR is determined by calculating the effluent values for the median (50th percentile) facility in the universe or sample. ASR values developed by States must be submitted to EPA for approval. A summary of the statistical analysis used by the State to develop the ASR values must also be submitted and, if consistent with the ASR development criteria above, will serve as the basis for EPA approval.

D. ISSUES FOR CONSIDERATION IN DEVELOPING ASRs

The purpose of the ASR provisions is to allow States flexibility in tailoring effluent requirements that take into account variations in plant performance attributable to differences in climatic or seasonal conditions. In order to preserve the intended flexibility, the criteria have been written to allow States to address issues that may arise because of a number of factors. These factors include, but are not limited to: climatic or seasonal differences with a State, similarities in climatic or seasonal conditions among contiguous States, and variations in the performance of different forms of trickling filters and ponds. All of these factors were considered to some extent in developing the adjusted SS values for ponds. As can be seen in Table VII-1, Some States established different SS values for ponds in different geographical areas of their States; contiguous States with similar climatic conditions frequently adopted the same SS value; some States established seasonal values; some States differentiated between different forms of ponds. Some of the issues involved in implementing ASRs are discussed below.

1. Sample Size

A major issue in considering disaggregation of the data within a State (or in aggregating the data for facilities in contiguous States of geographical areas), is whether the size of universe (or sample) of eligible facilities with adequate data is large enough to enable the analyst to draw relevant conclusions about the performance of trickling filters and pond facilities. Where a limited number of facilities exist within a given single State, the EPA Regions should coordinate the efforts of contiguous States in developing ASRs based on the all facilities operating within a geographical area of similiar seasonal and climatic conditions. Care should be taken in disaggregating a sample within a State (based on climatic or process differences) to ensure that the basis of such differentiation can be shown to be significant. Disaggregation should not be used if it would result in a limited sample size.

2. Differences in Process Types

Under the final rule, a State could recommend any of the following:

- A single ASR for both trickling filters and waste stabilization ponds, including all variants of those processes.
- An ASR for trickling filters and a separate ASR for waste stabilization ponds, or variants of those processes.
- An ASR for only one process (or variant of a process), with acceptance of the national requirements for the remaining process (or process variants).

The decision to establish different requirements based on the process used will involve consideration of observed differences in the performance of various processes or process variants. Ease of administration suggests that a single ASR for all eligible facilities, trickling filters, ponds and all their variants, should be developed, unless the data indicate a significant and compelling basis for setting separate values. It should be noted that the establishment of separate values for different processes or process variants will tend to result in limited sample·sizes that may not be representative.

3. Seasonal Requirements

Simply put, the need for an ASR will be based primarily on the inability of facilities within a State or appropriate contiguous geographical area to meet consistently the national performance standard. The use of a 95th percentile 30-day average value will tend to result in characterizing a plant's effluent quality on the basis of its performance under the most adverse operating conditions. Since these conditions may be seasonal in nature, e.g., limited to winter months of November through March, it may be appropriate to develop ASRs that apply only during certain seasons of the year. Particularly in northern climates, States should consider analyses of data that would identify and account for any seasonal differences in performance. Where such differences are significant, e.g., the summer time 30-day average BOD_5 values are less than 45 mg/L, but winter time 30-day average BOD_5 values are 50 mg/L or greater, a seasonal ASR may be appropriate.

TABLE VII-1
Suspended Solids Limitations for Wastewater Treatment Ponds ** [SOURCE: 43 FR 55279, November 27, 1978]

Location	Suspended Solids Limit * (mg/L)
Alabama	90
Alaska	70
Arizona	90
Arkansas	90
California	95
Colorado	
Aerated Ponds	75
All Others	105
Connecticut	N.C.
Delaware	N.C.
District of Columbia	N.C.
Florida	N.C.
Georgia	90
Guam	N.C.
Hawaii	N.C.
Idaho	N.C.
Illinois	37
Indiana	70
Iowa	
Controlled Discharge, 3 cell	case-by-case but not greater than 80
All Others	80
Kansas	80
Kentucky	N.C.
Louisiana	90
Maine	45
Maryland	90
Massachusetts	N.C.
Michigan	
Controlled Seasonal Discharge	
Summer	70
Winter	40
Minnesota	N.C.
Mississippi	90
Missouri	80
Montana	100
Nebraska	80
North Carolina	90
North Dakota	
North and East of Missouri River	60
South and West of Missouri River	100
Nevada	90
New Hampshire	45
New Jersey	N.C.
New Mexico	90
New York	70

(TABLE VII-1 Continued)

Suspended Solids Limitations for Wastewater Treatment Ponds**

Location	Suspended Solids Limit * (mg/L)
Ohio	65
Oklahoma	90
Oregon	
East of Cascade Mts.	85
West of Cascade Mts.	50
Pennsylvania	N.C.
Puerto Rico	N.C.
Rhode Island	45
South Carolina	90
South Dakota	120
Tennessee	100
Texas	90
Utah	N.C.
Vermont	55
Virginia	
East of Blue Ridge Mts.	60
West of Blue Ridge Mts.	78
East slope counties	case by case application of 60/73 limits
Loudoun, Fauquier, Rappahannock, Madison, Green, Albemarle, Nelson Amherst, Bedford, Franklin, Patrick	
Virgin Islands	N.C.
Washington	75
West Virginia	80
Wisconsin	60
Wyoming	100
Trust Territories and N. Marianas	N.C.

NOTES:

N.C. - no change from existing criteria

* Thirty consecutive day average or average over the period of discharge when the duration of the discharge is less than 30 days.

** The values set for Iowa and Virginia incorporate a specific case-by-case provision; however, in accordance with 40 CFR 133.103(c), adjustments of suspended solids limitations for individual ponds in all States are to be authorized on a case-by-case basis.

SECTION VIII

GUIDANCE FOR IMPLEMENTING NPDES PERMIT ADJUSTMENTS

A. INTRODUCTION

As noted in Section VII of this document, in order to account for differing geographical and climatic conditions which affect treatment plant performance, permit effluent limitations for eligible trickling filters and ponds may be based on the level of effluent quality attainable by a given facility. (In all cases, NPDES permit effluent limitations are not allowed to exceed either the nationally established BOD_5 and SS values or alternative State requirements as described in Section VII.) For existing facilities, the permit values are based on the facility's past performance record. For new facilities, the permit values reflect the design capabilities of a treatment process taking into account geographical and climatic conditions. The implementation of this "anti-backsliding" provision requires the permit writer to establish the NPDES permit effluent limitations for specific POTWs based on the performance capability of the individual facilities. This section provides guidance for permit writers to ensure that effluent limitations properly characterize the performance capabilities of the affected facility.

B. ANALYSES FOR EXISTING FACILITIES

1. Eligibility Requirements

The eligibility of a POTW for permit adjustments under this proposal is contingent upon the use of trickling filter or waste stabilization pond as the principal process, the achievement of significant biological treatment (65 percent removal of BOD_5), and a demonstration that the effluent quality consistently achieved through proper operation and maintenance of the treatment works exceeds the current secondary treatment requirements. The regulations would require that the characterization of the effluent quality consistently achieved by the facility based on a 95th percentile of the 30-day average BOD_5 and SS in a two-year period, excluding values attributable to upsets, bypasses, operational errors, or other unusual conditions. These determinations can be based on operating data for a facility, which is available through Discharge Monitoring Reports, Compliance Inspection Reports, or Operation and Maintenance Inspection Reports.

2. Determination of Effluent Values in Adjusted Permit

(a) Properly Operated and Maintained Facilities. If the two-year data base does not include any values attributable to upsets, bypasses, operational errors, or other unusual conditions and the facility is at design flow and loading, then the performance of the facility can be characterized in terms of the 30-day average (95th percentile), 7-day average (1.5 times the 30-day average), and percentage removal. If the derived values are consistent with current secondary treatment requirements, then the facility is not eligible for a permit adjustment. If the derived values exceed the current requirements, then the permit may be adjusted to those values, provided that they do not exceed the national standard or any applicable alternative State requirements.

(b) Improperly Operated and Maintained Facilities. If the two-year data base includes values attributable to upsets, bypasses, operational errors, or other unusual conditions, the permit should be written based on the effluent quality the facility should be capable of producing. Similar facilities can serve as the basis for a decision. If computer evaluation programs are available such as CAPDET or the Diagnostic Operational Modeling Program they can also be used to formulate a decision.

In reviewing the composite data for such facilities, all factors specific to the POTW being permitted should be examined. POTW design and influent differences that should be considered include:

- any unusual organic and hydraulic influent loading;
- any industrial waste contributions of greater than 10% of the total organic or hydraulic capacity of the facility;
- any unusual design criteria such as -- high or low process loading rates, recycle rates, detention times, etc.

The following factors should also be considered in determining whether poor O&M that is limiting plant performance:

- out-of-service equipment;
- excessive solids concentration in clarifiers;
- a lack of operational control testing or records including flow records, sludge depth in clarifiers, recycle rates;
- excessive bank erosion or growth around lagoons;
- improper operating depth or discharge procedures for lagoons.

(c) Underloaded Facilities

If a plant is currently underloaded in terms of its design conditions, it is appropriate for the permit effluent limitations to reflect performance capabilities of the plant at design loading and flow conditions . One approach to permitting that can be utilized is the establishment of two sets of limitations for two different flow values, i.e., the existing flow and the design flow. Once again computer evaluation programs can be valuable in establishing limits for the design flow situation. When utilizing computer programs, however, any limitations presented in the program's user manual must be considered. The effluent quality data that is provided by these programs should never be used as the sole source of a decision on permit effluent limits. The experience of O&M and enforcement personnel should be utilized to assess the level of effluent quality that the POTW is capable of producing.

(d) Seasonal Effluent Limitations. As in considering seasonal effects in establishing ASRs (see Section VII), permit writers may also consider seasonal effluent limitations if the composite data indicate that seasonal trends in effluent quality are ocurring.

C. ANALYSES FOR NEW FACILITIES

The permitting of new facilities requires greater reliance on permitting authorities' experience because of the lack of performance data. The performance of recently constructed facilities within a State may provide a better basis for establishing appropriate effluent limitations. However, where such effluent data are not available in an individual State, plant data from recently constructed facilities in surrounding States with similar conditions may be appropriate. The determination of effluent limitations for new facilities should follow the statistical approach for other equivalent treatment standards, described in Section VI. Additionally, States should perform this analysis upon promulgation of the regulation and disseminate the results to municipal officials and consulting engineers within the State.

As noted in Section III of this document, the EPA "Innovative and Alternative Technology Assessment Manual" (Ref. 14) provides a general reference for effluent quality attainable by trickling filters and ponds, together with accepted values for loading rates and other design criteria for most facility types. As a further general indication, data used in the analysis of trickling filter and pond process (see Sections V and VI of this document) suggest that, on a national basis, new trickling filters can be expected to achieve a 30-day average BOD_5 and SS effluent of approximately 35 mg/L; however, it should be noted that varying temperature conditions, especially when minimum influent wastewater temperatures fall within the range of 13°C or less, may result in higher values.

In evaluating the effluent limitations for new facilities, the permit writer should address the seasonal effects on the performance of the proposed process, and any other factors that may result in effects on the expected performance of the facility. For example, process innovations or additions, such as chemical addition, covers on trickling filters, the trickling filter-solids contact process, will frequently be proposed where they enable the facility to achieve a significant improvement in effluent at relatively moderate cost.

SECTION IX

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SECTION X

ABBREVIATIONS AND SYMBOLS

BOD_5	Biochemical oxygen demand, five day
COD	Chemical oxygen demand
exp	Exponential
ln	Natural logarithm
MGD	Million gallons per day
m_x	Long-term mean of effluent value (x)
mg/L	Milligrams per liter
N	Total number of sample values
NPDES	National Pollutant Discharge Elimination System
s_{x30}	Standard deviation calculated from lognormal distribution
SS	Suspended Solids
V_{x_N}	Coefficient of variation of effluent value (x) for n-day average values
VF	Variability Factor
VF_N	Variability Factor for time period, N
Z	Standardized normal variate at a given degree of probability
(X_i)	the i-th value in a total of N values, see N
u	mean
E	Summation
o_{x_N}	Standard deviation of the n-day average values from the overall mean (m_x)
o^2	Variance

SECTION XI

APPENDICES

A. Glossary
B. Legislative History
C. Summary Fact Sheets for Selected Biological Treatment Systems
D. Summary of Compliance Frequency by Treatment Process Type
E. Technical Data Summary Tables, by Treatment Process Type
F. Technical Data Summary for Processes and Facilities In Treatment Equivalent to Secondary Treatment Category

APPENDIX A

GLOSSARY

GLOSSARY

1. "7-day average." The arithmetic mean of pollutant parameter values for samples collected in a period of 7 consecutive days.

2. "30-day average." The arithmetic mean of pollutant parameter values for samples collected in a period of 30 consecutive days.

3. "Act." The Clean Water Act (33 U.S.C. 1251 et seq., as amended).

4. "Arithmetic average." The sum of all the data values divided by the number of data points.

5. "BOD_5." The five day measure of the pollutant parameter biochemical oxygen demand (BOD).

6. "Calendar average." The arithmetic mean of pollutant parameter values collected over a specified period (e.g., 7 or 30 consecutive days).

7. "COD." Chemical oxygen demand.

8. "Coefficient." A numerical measure of a physical or chemical property that is constant for a system under specified conditions.

9. "Correlation coefficient." A measure of the interdependence of two random variables; ranges in value from -1 to +1, indicating perfect negative correlation at -1, absence of correlation at 0, and perfect positive correlation at +1.

10. "Design flow." Influent flow rate at which wastewater treatment facility was designed to operate.

11. "Effluent." Discharge from a wastewater treatment facility into receiving waters.

12. "Effluent concentrations consistently achieved through proper operation and maintenance." For a given pollutant parameter, the 95th percentile value for the 30-day average effluent quality achieved by a treatment works in a period of at least two years, excluding values attributable to upsets, bypasses, operational errors, and periods of unusually high strength wastewater.

13. "Facilities eligible for treatment equivalent to secondary treatment." Treatment works shall be eligible for consideration for effluent limitations described for treatment equivalent to secondary treatment (§ 133.105), if:

    (1) the BOD_5 and SS effluent concentrations consistently achieved through proper operation and maintenance (§ 133.101(f)) of the treatment works exceeds the minimum level of effluent quality set forth in § 133.102(a) § 133.102(b)).

(2) a trickling filter of waste stabilization pond is used as the principal process, and

(3) the treatment works provide significant biological treatment of municipal wastewater.

14. "Flow." The amount wastweater moving in a given period of time.

15. "Geometric average." The positive nth root of a product of n factors.

16. "Hydraulic detention time." In biological wastewater treatment processes, the time that the mixed liquor suspended solids (MLSS) spend in the reactor basin (i.e., where the microorganisms are brought into contact with the organic components of wastewater).

17. "Hydraulic loading rate." Wastewater flow rate treated by a wastewater treatment process system.

18. "Infiltration/Inflow (I/I)." Water other than wastewater entering a sewer system; includes such sources as groundwater and stormwater.

19. "Influent." Untreated wastewater entering a wastewater treatment facility.

20. "Kolmogorov-Smirnov goodness-of-fit test." A method for determining the capability of a probability distribution model to describe a given set of data.

21. "Major facility." Wastewater treatment plant with flow of equal to or greater than 1 MGD.

22. "Mean." Average value of a series of data. Usually the arithmetic mean.

23. "Median." The middle value when the data are arranged in ascending or descending order.

24. "MGD." Million gallons per day.

25. "mg/l." Milligrams per liter.

26. "Minor facility." Wastewater treatment plant with a flow of less than 1 MGD.

27. "Mixed liquor." Mixture of activated sludge, primary effluent or raw wastewater, and return sludge in the aeration tank of an activated sludge process.

28. "Mixed liquor suspended solids." The suspended solids in the mixed liquor or an aeration tank.

29. "Mode." The most frequently occurring value in a data set.

30. "NPDES." National Pollutant Discharge Elimination System.

31. "Organic loading rate." The rate at which organics measured by BOD, are added to the mixed liquor in the aeration tank in a biological wastewater treatment process.

32. "Pearson correlation coefficient." Measures the relationship between two sets of data; the closer the coefficient is to 1, the more linear the relationship between the data sets.

33. "Percent removal." A percentage expression of the removal efficiency of a treatment works for a given pollutant parameter, as determined from the 30-day average values of the influent pollutant concentrations to the facility and the 30-day average values of the effluent pollutant concentrations for a given time period.

34. "Probability distribution." The probability pattern that gives the relative likelihood associated with all possible values of a variable.

35. "Process parameters." The variables associated with the operation of a wastewater treatment facility.

36. "Process volume." The capacity of a biological treatment unit of a wastewater treatment facility.

37. "Randomness." Characteristics of a data set that does not exhibit cycles or patterns or that is generated such that each data point has an equal chance of being sampled.

38. "Reliability." The percent of the time that effluent concentrations are achieved.

39. "Runs test." General purpose test of the randomness of a data series.

40. "Serial correlation test." A test for the correlation between consecutive data pairs used to test for randomness of a data series.

41. "Significant biological treatment." The use of an aerobic or anaerobic biological treatment process in a treatment works to consistently achieve a 30-day average of at least 65 percent removal of BOD_5.

42. "Skewness." A measure of the symmetry of the data about the mean. When the skewness is approximately equal to zero, the distribution of the data about the mean is symmetric. For positive values of skewness, the distribution of the data is clustered more to the left of the mean and has a longer tail to the right. For negative skewness, the data more clustered to the right of the mean with a longer tail to the left.

43. "Sludge age." A measure of the length of time a particle of suspended solids has been undergoing aeration in the activated sludge process.

44. "Solids loading rate." The rate at which suspended solids are added to the mixed liquor of an aeration tank in a biological wastewater treatment process.

45. "Spearman rank order correlation coefficient." Measures the relationship between the rankings of two sets of data. Indicates nonlinear relationships between the data sets.

46. "Standard deviation." A measure of the degree of dispersion or spread of the data about the mean value; expressed in the same units as the data; the square root of the variance.

47. "TF." Trickling filter.

48. "TOC." Total organic carbon.

49. "Variance." A measure of the degree of dispersion or the data about the mean value. The smaller the variance the more closely the individual data points are clustered about the mean; expressed in terms of the squared units of the sample data values.

50. "Volatile MLSS." The organic or volatile suspended solids in the mixed liquor of an aeration tank of a biological wastewater treatment process.

51. "WSP." Waste stabilization pond.

APPENDIX B

LEGISLATIVE HISTORY

Public Law 97-117
97th Congress

An Act

To amend the Federal Water Pollution Control Act to authorize funds for fiscal year 1982, and for other purposes.

Dec. 29, 1981
[H.R. 4503]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE

Municipal Wastewater Treatment Construction Grant Amendments of 1981.
33 USC 1251 note.

SECTION 1. This Act may be cited as the "Municipal Wastewater Treatment Construction Grant Amendments of 1981".

SECONDARY TREATMENT DEFINITION

33 USC 1314.

SEC. 23. Section 304(d) of the Federal Water Pollution Control Act is amended by adding the following new paragraph:

"(4) For the purposes of this subsection, such biological treatment facilities as oxidation ponds, lagoons, and ditches and trickling filters shall be deemed the equivalent of secondary treatment. The Administrator shall provide guidance under paragraph (1) of this subsection on design criteria for such facilities, taking into account pollutant removal efficiencies and, consistent with the objective of the Act, assuring that water quality will not be adversely affected by deeming such facilities as the equivalent of secondary treatment.".

Approved December 29, 1981.

LEGISLATIVE HISTORY—H.R. 4503 (S. 1716):

HOUSE REPORTS: No. 97-270 (Comm. on Public Works and Transportation) and No. 97-408 (Comm. of Conference).
SENATE REPORT No. 97-204 accompanying S. 1716 (Comm. on Environment and Public Works).
CONGRESSIONAL RECORD, Vol. 127 (1981):
Oct. 27, considered and passed House; S. 1716 considered and passed Senate.
Oct. 29, considered and passed Senate, amended, in lieu of S. 1716.
Dec. 6, House and Senate agreed to conference report.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 17, No. 53 (1981):
Dec. 29, Presidential statement.

97TH CONGRESS
1st Session

HOUSE OF REPRESENTATIVES

REPORT
No. 97-408

MUNICIPAL WASTEWATER TREATMENT CONSTRUCTION GRANT AMENDMENTS OF 1981

DECEMBER 14, 1981.—Ordered to be printed

Mr. ROE, from the committee of conference,
submitted the following

CONFERENCE REPORT

[To accompany H.R. 4503]

The committee of conference on the disagreeing votes of the two Houses on the amendment of the Senate to the bill (H.R. 4503) to amend the Federal Water Pollution Control Act to authorize funds for fiscal year 1982, and for other purposes, having met, after full and free conference, have agreed to recommend and do recommend to their respective Houses as follows:

That the House recede from its disagreement to the amendment of the Senate and agree to the same with an amendment as follows:

In lieu of the matter proposed to be inserted by the Senate amendment insert the following:

DEFINITION OF SECONDARY TREATMENT

House bill

No comparable provision.

Senate amendment

Section 304(d) of the basic Act is amended by adding a new paragraph permitting the use of biological treatment facilities such as oxidation ponds, lagoons and ditches, trickling filters, and devices to treat waste waters from combined storm and sanitary sewers, as the equivalent of secondary treatment if it can be proven that water quality will not be adversely affected by such methods.

Conference substitute

Same as Senate amendment, except that the reference to combined storm and sanitary sewers is deleted.

Calendar No. 296

97TH CONGRESS }
1st Session }
SENATE
{ REPORT
{ No. 97-204

CLEAN WATER ACT AMENDMENTS OF 1981

OCTOBER 7, 1981.—Ordered to be printed

Mr. CHAFEE, from the Committee on Environment and Public Works, submitted the following

REPORT

[To accompany S. 1716]

* * * *

[17]

SECTION 20.—DEFINITION OF SECONDARY TREATMENT

Section 304(d) of the Clean Water Act is amended by adding a new paragraph permitting the use of biological treatment facilities such as oxidation ponds, lagoons and ditches, trickling filters, and devices to treat waste waters from combined storm and sanitary sewers, as the equivalent of secondary treatment if it can be proven that water quality will not be adversely affected by such methods.

Under authority of existing law, the Administrator of the Environmental Protection Agency has defined the term "secondary treatment" as the removal of 85 percent of biological oxygen demand (BOD) and the attainment of an effluent containing not more than 30 milligrams per liter of suspended solids over a 30 day period. Methods of achieving secondary treatment are also at the discretion of the Administrator.

* * * *

[18]

Certain biological treatment techniques such as oxidation ponds, trickling filters, and devices to treat combined storm and sanitary wastes have proven effective in achieving significant reductions in BOD and TSS. These methods for the most part are cheaper and more energy-efficient than standard methods, and are particularly useful in smaller communities. Yet the Environmental Protection Agency has not sanctioned their use for secondary treatment.

This section therefore permits the use of certain biological treatment facilities to meet the secondary treatment requirement provided that water quality and particularly the objective of the Act is not adversely affected, in spite of the fact that they may not consistently meet 85 percent removal. In developing the guidelines necessary to carry out this provision the Administrator should take into account not only pollutant removal efficiencies, but also differing geographical/climatic conditions which affect treatment plant performance. The Administrator should also address the seasonal and geographical variability of biological treatment plant performance in the regulations issued to carry out this section.

The Committee is also concerned with the water quality impacts of any revision to the secondary treatment definitions. Although water quality impact is not a consideration in defining technology-based regulations, a technology would not be acceptable for any category of dischargers if it is found that the technology is inadequate in terms of necessary water quality protection. This section is not intended to sanction the introduction of raw sewage into the Nation's waterways. The basic water quality test is that found in section 101(a) of the Clean Water Act.

The Committee recognizes that serious water quality problems in marine bays and estuaries can result from wet weather discharges of wastewater from combined storm sanitary sewer systems. Because of this, cost-effective devices to treat and store such discharges may be considered the equivalent of secondary treatment and be eligible for Federal grant assistance. The Administrator should prepare guidance on the types of devices to be considered in the cost effectiveness analysis of combined sewer overflow correction and the performance criteria for such facilities.

During Subcommittee hearings it was brought out that some communities have unsuccessfully sought EPA's assistance in proceeding directly to systems which treat and recycle wastewater for potable supply. The City of San Diego in particular is attempting to meet its water supply needs in this manner. Clearly the goal of P.L. 92–500 is to encourage recycling and reuse of wastewater. In 1977 the Congress reaffirmed this position by including a special incentive program for innovative and alternate wastewater systems. This legislation carries that incentive program forward.

The fact that communities are turning to recycling systems is gratifying. Rather than refusing to provide assistance for such systems EPA should be encouraging more communities to investigate them. For that reason EPA should reconsider its position in this matter. More and more communities will be attempting to meet potable supply needs in this manner. Knowing that EPA will assist them will further encourage this.

[S 5525]

By Mr. CHAFEE (for himself, Mr. STAFFORD, and Mr. RANDOLPH):

S. 1274. A bill to amend title II of the Clean Water Act, and for other purposes; to the Committee on Environment and Public Works.

CLEAN WATER ACT AMENDMENTS OF 1981

● Mr. CHAFEE. Mr. President, on April 9, I introduced, by request, the Reagan administration's amendments to the Clean Water Act's construction grants program. Those amendments, as I pointed out at the time, take a significant step in shaping this year's debate about the future of this troubled program.

Recent news articles have pointed out many of the ills that have plagued the construction grants over the last 10 years. This has been the second largest Federal public works program in history. Congress has appropriated more than $30 billion for this program, and more than $29 billion has been spent.

Where are we today

We have had some successes. There is no doubt that the rivers of this country are being cleaned up as a result of both industrial and municipal efforts to clean up waste discharges.

But because of the fiscal situation of this country, clearly the time has come to reassess the construction grants effort.

As I said on April 9, this effort is at the crossroads. In the past, the program has not been clearly defined as public works or environmental improvement. If it is to continue, that uncertainty must be cleared away.

The amendments I am proposing today are simple and straight-forward, and provide the program with the stability it needs. Yet it trims the program so it will run smoother, allow States to be able to spend their money in a more orderly fashion, and assure that projects which will truly benefit water quality will be funded first.

The Clean Water Act Amendments of 1981 call for an extension of this program through fiscal year 1985 at the level equal of the administration—$2.4 billion per year. I am pleased to say that three-quarters of the administration's request have been incorporated into my legislation.

Under my amendments, the Federal Government would gradually reduce its commitment to this program by lowering the Federal share from its current 75 percent on traditional waste treatment facilities down to 55 percent by the end of this authorization. I do not enjoy doing this but the fact is that we have less money to deal with and we have to spread it just as far.

The impact of this will be great.

First, it will lower Federal exposure in terms of future funding of this program.

In addition, it will require the States and municipalities to take a harder look at the plans they are developing to meet their wastewater treatment needs.

The large Federal share has been in some cases, a villian. It has pushed some communities to bypass difficult decisions and to build expensive, oversized plants that now do not meet the specifications for which they were designed and have operation and maintenance costs which are stressing local budgets to the limit. These amendments should begin to cure that problem.

Another amendment that will assist that effort is the proposed termination of the Federal funding for the planning phases of waste-water treatment facilities.

Presently, grantees apply and receive funding quickly and rapidly for facilities that may or may not ever be built, but because the large Federal share—75 percent—is available, plans and studies are done.

In the future, if these amendments are enacted, only communities which receive a construction grant will be reimbursed for the Federal share of the planning phase of their project. As a result the Environmental Protection Agency must in turn, back off from the interference it makes in the local decisionmaking process.

It will be required to approve only the finished product. At the present time, there are too many steps in the process of building these facilities that slow it down to the point that from inception to completion, construction averages 9 full years. If these amendments are enacted, I would expect to see that time cut in half.

Other provisions of this legislation will also give us a better handle on where this program is going. Many communities have used this program not to clean up pollution but instead to build for future growth and economic development.

While these are important goals, I question whether a Federal pollution control program should be picking up the tab for them.

These amendments provide Federal reimbursement only to the extent that the facilities meet the needs of the 1980 population as defined in our recent census.

This restriction will eliminate costly sewerlines that stretch out into open areas for future subdivisions and shopping malls. Again, this provision is one which will have significant environmental benefits and also will reduce the future Federal budgetary exposure.

Another provision of these amendments requires that projects which will receive funding in the future shall be placed on a State's funding priority list based on their impact on water quality. At the present time, priority lists are a function more of construction schedules than water quality.

If this program is to continue and the Federal share is to be reduced, those projects which will have the greatest significant benefit on water quality should move to the top of the priority list in order to receive the largest Federal share possible.

In keeping with past traditions of the Environment and Public Works Committee, these amendments seek to encourage State and local governments to find innovative and alternative solutions to municipal pollution problems.

These amendments provide a significant incentive by allowing the Federal Government to pay for proportionally 20 percent more than a traditional facility if communities seek innovative and alternative solutions.

As I stated on April 9, we must not lose sight of the fact that this program will remain a water quality improvement program, and in many parts of the country traditional wastewater treatment facilities simply will not provide enough cleanup.

For that reason, I have included in these amendments discretionary authority for the EPA administrator to deal with the problem of combined storm and sanitary sewer overflows into ecologically critical bays and estuaries that will not otherwise be cleaned up by traditional treatment.

I feel very strongly that these bays and estuaries should receive a priority. I know in our part of the country—New England—Narragansett Bay and Boston Harbor, support thriving fishing and recreation industries. Without some attention being paid to the problems of combined sewer overflows, these great bays, which are environmental and economic resources to their States, will simply not receive the attention they should.

To provide just traditional waste treatment would be throwing good money at projects that will not show demonstrable gains in water quality. This is poor policy for the environment and poor policy for the budget. If we are going to spend limited Federal dollars, we should make sure we spend them correctly.

A new provision requires the engineers responsible for the design and construction of the treatment facilities to remain on the job after the end of construction and be liable for the plants meeting the specifications for which they were designed. This will protect communities having facilities which are costly to build, yet fail to live up to their promise.

Last, these amendments contemplate something I am not so sure anyone before has ever contemplated—completing the program. The amendments require the EPA Administrator to report to the Congress within 18 months on the impact of these amendments on completing this program. As I stated on April 9, when I

[S 5526]

introduced the administration bill, the goal is two pronged—fiscal soundness and environmental improvement.

I share President Reagan's goal that the Federal exposure in this program should be reduced gradually over time. These amendments do that by anticipating the completion of this program and reducing Federal share.

States that have operated under the illusion that all projects will eventually be completed will have to make difficult choices about which projects will receive priority. It may not be easy, but it will be necessary.

What we accomplish this year will set the tone for the next decade. My goal is to trim the program, but at the same time make certain that whatever budget trimming is done also improves our Nation's water quality. These amendments, if enacted, will greatly address both those issues.

Hearings are scheduled in June, and we expect to complete action on this program by the end of this fiscal year in order to have appropriations for fiscal year 1982 in place so that States and local governments can plan accordingly.

At this point I would ask unanimous consent to print the bill in the RECORD.

There being no objection, the bill was ordered to be printed in the RECORD, as follows:

S. 1274

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Clean Water Act Amendments of 1981".

* * *

[S 5527]

SEC. 18. Section 304(d) of the Clean Water Act is amended by adding the following new paragraph:

"(4) For the purposes of this subsection, such facilities as oxidation ponds, lagoons, and trickling filters shall be deemed the equivalent of secondary treatment when the owner or operator of a publicly owned treatment works makes a showing satisfactory to the Administrator that, taking into account local climate, the limited population served, and assurances as to the operation and maintenance of such facility, water quality will not be adversely affected by deeming such facilities as the equivalent of secondary tratment.".

CONGRESSIONAL RECORD — HOUSE *October 27, 1981*

[H 7776]

● Mr. GOLDWATER. Mr. Chairman, I am pleased to rise in support of H.R. 4503, the Federal Water Pollution Control Act Amendments of 1981, as a worthwhile bill in its own right, as a prerequisite for continued funding of the construction grants program, and as a forerunner of further reforms when the Clean Water Act undergoes further modification next year.

As to funding, its construction grants authorization of $2.4 billion for fiscal year 1982 is modest indeed in comparison with the $4 billion, $5 billion and even $6 billion in annual authorizations during the early years of the program under Public Law 92-500. The Committee on Public Works and Transportation has been responsive to legitimate budgetary concerns in this regard.

H.R. 4503 is not, however, a mere simple extension of existing law, much less a pared-down version of business as usual. In fact, it contains a number of provisions to improve the performance of the construction grants program and the wastewater treatment works which it produces.

I would cite in particular the provisions dealing with the following:

Innovative and alternative technology, strengthening the incentives for processes and equipment that are cheaper, simpler and more energy efficient; continued eligibility for projects to correct sewer system infiltration and inflow as a cost-effective alternative to construction of larger treatment works; procurement of treatment processes and equipment, by the removal of a statutory restriction which serves to discourage innovation on the part of equipment manufacturers and to undercut responsibility of municipalities and their engineering consultants for the performance of treatment works constructed under the program; strengthening of the role of the States in managing the construction grants program, achieved by providing greater stability in funding.

These provisions in particular are supported by the record of hearings of the Subcommittee on Investigations and Oversight, on which I serve as ranking minority member. Under the leadership of my friend from Georgia, Mr. LEVITAS, we have just concluded the most thorough investigation ever undertaken into the performance of wastewater treatment works constructed with Federal assistance. The record of those hearings, conducted in a completely bipartisan manner, strongly supports the provisions of H.R. 4503 which I have cited. Thus, from an oversight perspective, it supports the work of Chairman BOB ROE of the Water Resources Subcommittee and his minority counterpart, JOHN PAUL HAMMERSCHMIDT.

With particular respect to innovative and alternative technology, I appreciate the full committee's acceptance of a modest amendment which I offered to help overcome reluctance on the part of grantees and their design engineers to consider innovative and alternative processes and components. In recognition of the fact that many promising ideas have had the benefit of only laboratory simulation or limited pilot testing, this provision makes more extensive field testing grant eligible to provide the missing element of verification as to performance capability.

All these aside, however, the bill would be justified if only by its amendments dealing with the issue of waivers from secondary treatment requirements for communities discharging their treated wastewater into marine waters through ocean outfalls. If it makes sense from an environmental and economic standpoint for communities with existing ocean discharges to treat to a degree lesser than full secondary, there is absolutely no rationale for denying this option to others provided they meet the same stringent water quality requirements.

The provisions of H.R. 4503 dealing with ocean waivers in fact closely parallel those of my own bill, H.R. 4466, which I introduced following an oversight hearing focused principally on the ocean discharge issue, held at my request in Los Angeles on September 8.

Mr. Chairman, none of us would argue that H.R. 4503 is a comprehensive bill providing all needed changes in the Clean Water Act. It does not even purport to deal with all the problems we have identified in the construction grants program.

But the committee has chosen to move in a more limited manner at this time, responding to concerns expressed by the administration and the other body, while properly preserving the constructive policy positions which the House has asserted for the past decade and more.

I urge my colleagues to support H.R. 4503 in its present form at this time, so we can move into conference with the Senate and seek to fashion a bill that will provide a basis for funding of the construction grants program through fiscal year 1982. Then we can turn our efforts to the task of crafting longer term amendments to both the regulatory and the construction grants aspects of the law which ultimately will be necessary if it is to do the job we all intend.●

Mr. GOLDWATER. Mr. Speaker, I rise in strong support of the conference report on H.R. 4503, the Municipal Wastewater Treatment Construction Grant Amendments of 1981, and comend it to my colleagues as a measure deserving adoption by an overwhelming vote and prompt signature by the President.

H.R. 4503, as reported by the Committee on Public Works and Transportation, was a sound piece of legislation, as I indicated in my comments on the occasion of its passage by the House on October 27. Now I would observe, on the basis of my work as ranking minority member of the Subcommittee on Investigations and Review, that the conference report contains a number of improvements.

This is absolutely no reflection on the work of the Water Resources Subcommittee or the full committee. It reflects, instead, the fact that the conference took up some issues which the House side had originally regarded as best deferred until next year. This was in the overriding interest of passing out an authorization bill to serve as the basis for a fiscal year 1982 appropriation for the construction grants program.

Indeed, the majority and minority leadership of both the subcommittee and full committee are to be commended for their contributions to this legislation, as are all of the House conferees for their able assertion of the House position in negotiations with the Senate.

During the 1st session of the 97th Congress, the Public Works Investigating Subcommittee has conducted the most comprehensive investigation every undertaken into the performance of the wastewater treatment works constructed with Federal Assistance under the Clean Water Act.

A subcommittee report now being issued lends strong support to many of the provisions of the measure now before us, including changes resulting from the conference deliberations:

MULTIYEAR FUNDING

Our hearings over a number of years have demonstrated that many of the ills plaguing the program can rightly be attributed to a lack of continuity, stability, and predictability. The 4-year authorization is most appropriate in this regard.

REDUCED FEDERAL SHARE

We concluded that, in addition to the need for this program to share in overall reductions in Federal spending, that a reduction of the Federal share to 55 percent from 75 percent—over an adequate transition period—should result in selection of less costly and more reliable treatment processes, and improved operation and maintenance by grantees.

MUNICIPAL COMPLIANCE DEADLINES

There is universal recognition that municipalities cannot meet the secondary treatment deadline of 1983 now in the law, what with reduced funding in recent years and other factors delaying initiation of projects. The shift of the outside deadline for compliance to 1988 from 1983 is absolutely critical. Members who recall the unsuccessful attempt by the House to make some adjustment in last year's amendments will applaud the Senate's new receptivity to reality.

SECONDARY TREATMENT REQUIREMENTS

Many problems of cost, overdesign, and construction of treatment plants that are difficult to operate justify the conference report's authorization of less sophisticated treatment technologies such as oxidation ponds, lagoons, and ditches, and trickling filters, provided no harm to water quality results.

ELIGIBLE CATEGORIES

Retention of grant eligibility for projects to eliminate excessive overloading of sewer systems by storm water will make it possible to continue repair projects that protect the functioning of treatment works and avoid the need for additional plant capacity.

I particularly want to express my appreciation to the House conferees for essentially preserving the House position on the granting of waivers from secondary treatment requirements to coastal communities discharging treated wastes into marine waters under strict environmental safeguards.

It also is gratifying that the conference retained my provision to make grant eligible the field testing of innovative and alternative processes and equipment where necessary to promote acceptance of promising developments.

Also of merit in the conference report are provisions to modify procurement requirements affecting wastewater treatment equipment, sustain a strong State role in management of the construction grants program, and further strengthen incentives for development of innovative and alternative technology.

Specific provisions aside, I just want to say a word about the approach to the changes in this bill, whether related to Federal share or categories of project eligibility. The word is gradual. There is a phased-in transition provided that should make it much easier for localities to adjust to these changes in the law.

Recently our subcommittee held a hearing in Austin, Tex., on the practical implications of a number of proposed changes in the act. And if any message came through loud and clear it was that the municipalities subject to the law's requirements need time to adjust to changes. I am encouraged to believe that the phasing in of this legislation, plus the easing of compliance deadlines, should go far in helping them do so.

To be sure, there are many areas of the act—including the construction grants program in title II—that will need further attention in the next session of the 97th Congress. With respect to the construction grants program alone, our subcommittee has proposed a number of changes which have yet to be put forth in legislative form. They include:

[H 9829]

Consideration of alternative sources of funding.

Additional measures to increase the responsibility of grantees, such as withholding of a grant until the applicant operates any existing facilities with maximum efficiency, and withholding 20 percent of grant funding until a new facility performs as intended.

A strengthened role for the Environmental Protection Agency's Office of Inspector General in rooting out waste, fraud, and abuse.

Clearer and tighter lines of responsibility and accountability in the performance of design engineers, through such approaches as turnkey projects and reduced Federal interference in the design of facilities.

As I said, many of our oversight recommendations have yet to be formally offered on the assumption that the entire act will be reviewed again next year. But the extent to which our findings parallel the position taken by the conferees on the issues we both addressed suggests that our remaining recommendations—and earlier ones arising from our examination of the regulation of toxic pollutants—should find a receptive audience.

Meanwhile, I urge adoption of the conference report.

* * *

[H 9830]

Mr. LEVITAS. Mr. Speaker, I rise in support of this legislation and commend the chairman of the subcommittee and ranking member of the subcommittee for the outstanding work they did in putting together the bill that originally passed the House and this conference report. It has been a real example of cooperation between a legislative committee and oversight committee, because this bill incorporates substantially all of the recommendations which our oversight committee of the Public Works and Transportation Committee has made following a very and thorough comprehensive review of the entire construction grants program during the last year.

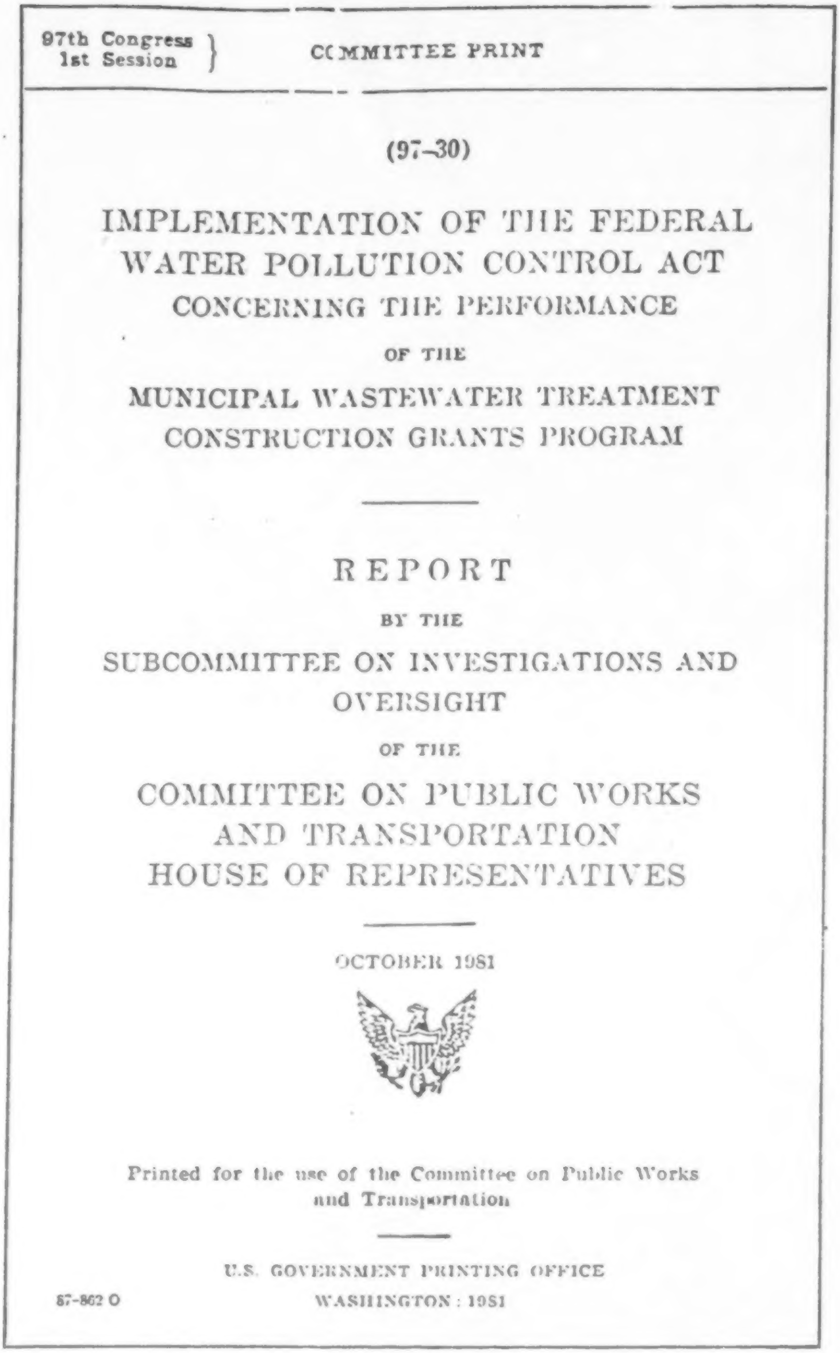
The water pollution control program is a program that is so vital to the quality of life in this country and to the economy of this Nation that it could not be left to founder because it was not working well. That is the reason an oversight review was vital and the need for the types of reforms and changes in the program which this conference report reflects I think will go a long way to carrying out the types of reforms which our oversight committee has recommended. The two subcommittees worked closely, both among the members and the two staffs, in seeing this reform come about.

[H 9831]

There are some additional administrative improvements that need to be made and we will continue our oversight of the Environmental Protection Agency to see that improved management in these operations is going to be seen.

But I think we have got to focus on both the quality of life and the economic impact of this program. Clean water is essential to a good and a full and a healthy life. It is also essential to our economy.

* * *



97th Congress }
1st Session }
COMMITTEE PRINT

(97-30)

IMPLEMENTATION OF THE FEDERAL WATER POLLUTION CONTROL ACT CONCERNING THE PERFORMANCE OF THE MUNICIPAL WASTEWATER TREATMENT CONSTRUCTION GRANTS PROGRAM

REPORT

BY THE
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
OF THE
COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
HOUSE OF REPRESENTATIVES

OCTOBER 1981

Printed for the use of the Committee on Public Works and Transportation

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(97–30)

[27]

THE INCENTIVE TO PERFORM

* * *

[34]

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Effluent limitations and permit requirements

The 1972 Act prescribed secondary treatment as the national minimum required for all municipalities, but left to the discretion of EPA the definition of secondary and thus, the degree of treatment to be provided. While the law gave EPA some latitude in setting secondary treatment requirements, the agency chose not to use it, issuing instead one narrow and uniform set of requirements limiting discharges to a maximum of 30 parts per million each of biochemical oxygen demand and total suspended solids, and requiring that secondary treatment technologies remove 85 percent of the pollutants entering the plant, on a monthly average basis.

The uniform effluent limitation for secondary treatment in combination with EPA's reliance on them as a regulatory standard, has contributed to the design and construction of sophisticated and costly plants. This in turn has given rise to complaints of over-design and the need to upgrade or replace plants employing simpler processes that could not meet the new performance requirements, even though these plants were operating well in terms of achieving their original design performance levels. Further, the lack of time and adequate personnel during the early years of the program did little to help avoid this problem.

The 1972 law gave the EPA 26 months to develop standards for secondary treatment and issue more than 20,000 municipal discharge permits containing those standards and schedules for meeting them. Unfortunately, it took the EPA 10 months just to develop the secondary treatment definition, leaving both federal and State regulatory officials in a mad scramble to issue the required permits and to begin reviewing and approving municipal applications for construction grants.

As a result, many if not most of the first round of municipal permits were simply pieces of paper inscribed with the EPA definition of secondary treatment, the law's July 1, 1977 compliance deadline substituting for a realistic schedule of compliance. Efforts to inspect

[35]

and evaluate a plant's capability to meet the new secondary treatment requirement or to determine just how long it would take to construct necessary facilities were the exception rather than the rule. And in those few instances where efforts were made, they were often perfunctory in nature due to the lack of knowledge on the part of EPA or State personnel about treatment plant technology or construction. The comments of the Water Pollution Control Federation's President, Carmen Guarino described what was believed typical at the time:

> Early in the game when we were trying to set schedules, I visited the regulator who was concerned with setting the time that it takes to build a treatment plant. He said to me, "Carmen, how long is it going to take you to build that treatment plant?" I said, "It is going to take at least five years." He said, "Oh, come on; it will not take five years. I have a friend in the construction business; I am going to call him and ask him how long it would take to build a treatment plant." He picked up the phone in my presence and called the contractor. He said, "Hey, Joe, how long do you think it would take to build one of these plants in Philadelphia? I think it would take two years. Do you agree with me?" The fellow said, "Yes, I think it would take two years." He said, "Carmen, you have got two years to build that treatment plant." That official's decision cost Philadelphia half a million dollars in lawsuits, consent decrees, and everything else.

The EPA definition of secondary also frequently imposed higher capital and operating costs on grantees, many of them small communities and sanitation districts, resulting from the more sophisticated technologies needed to meet the new standard and a need for higher plant operating skills and management capabilities.

Generally, these situations stem from the fact that while the definition of secondary treatment is narrow and uniform, water quality conditions and the amounts of wastes dumped into any given body of water are not. Naturally occurring differences in a stream flow, mineral content, temperature, and other factors affect its "assimilative capacity," its ability to absorb wastes. Consequently, while secondary treatment, as defined, may be appropriate for some situations, it is inevitably either too much or too little for many others.

The Act and EPA give recognition to these factors, but only in terms of upward adjustments. If secondary treatment is inadequate to protect water quality, higher levels of treatment are required. But in cases where secondary is excessive and yields no benefit, there can be no adjustment downward.[11] This in effect, has led to costly treatment for treatment's sake, absorbing funds which could be used elsewhere to greater environmental benefit.

According to unpublished EPA data, more than $1 billion (in 1980 dollars) could be saved in the future simply by broadening the existing definition of secondary treatment to allow the use of alternative, less-costly forms of treatment which, while unable to meet the current definition's performance requirement, can provide enough treatment so as not to tax a stream's assimilative capacity.[12] Although

water quality analytical tools are still inadequate as the sole determinant of treatment requirements, many believe that the savings that can be realized by allowing some judgment to be used in determining which type or level of secondary treatment is necessary justify any risks involved. And, should a lesser level of treatment prove inadequate, more can always be added.

* * *

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[11] EPA's regulations allow for secondary treatment requirements to be exceeded, i.e., relaxed, in certain limited situations, such as when high volumes of industrial wastes are discharged into a municipal system, these wastes usually being significantly stronger than normal domestic sewage. However, the agency has only recently, in its current round of re-issuing expiring municipal discharge permits, begun to make any real use of this variance.

[12] Prior to the enactment of the 1972 Federal Water Pollution Control Act Amendments, which set out the technology based requirement that all communities have, as a minimum, secondary treatment, municipal (and industrial) treatment requirements were generally established on the basis of assessing a stream's assimilative capacity. Unfortunately, this water quality based approach was, and still is, too vague and subject to analytical weaknesses. This makes it difficult if not impossible to establish any correlation between a stream's actual water quality conditions and the presence of a discharge. As a result, many communities and industries found it easy to argue successfully that they were not the cause of observed water quality problems, and thereby avoided the costs of providing wastewater treatment.

COMMITTEE PRINT

(97–30)

[66]

* * *

X—Recommendations

* * *

[73]

19. THE LAW SHOULD BE AMENDED TO ALLOW A RANGE OF EFFLUENT LIMITATIONS APPLICABLE TO MUNICIPAL TREATMENT WORKS RATHER THAN A SINGLE, RIGID SET OF NUMBERS APPLICABLE ON A NATIONWIDE BASIS

It would be constructive to permit a range of effluent limitations which permit the use, where appropriate, of such forms of treatment as trickling filters, lagoons and ponds. Consideration should be given to basing the determination of appropriate secondary municipal technology on the general charateristics of the receiving stream, the nature of the wastes involved and the affordability of various secondary treatment processes available to the community. As to receiving waters, it should not be necessary to make precise determinations of wasteload allocations as done (with great imprecision) in the establishment of water quality based effluent standards. Instead, it should suffice to categorize generally the volume and rate of flow of the water body, and nature and sensitivity of the aquatic life inhabiting it. In other words, it should not take a 10-year study and endless computer runs to distinguish between a fishing stream and the Lower Mississippi River. There is a large range of both conventional and alternative technology available providing levels of treatment between primary and secondary for this purpose.

* * *

Elliott H. Levitas, *Chairman.*
Norman Y. Mineta,
Robert A. Roe,
Geraldine A. Ferraro,
Donald Joseph Albosta,
William Hill Boner,
Gus Savage,
Buddy Roemer,
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Arlan Stangeland,
Newt Gingrich,
Gerald B. H. Solomon,
Harold C. Hollenbeck,
Guy Molinari,
Bob McEwen,
Don H. Clausen, *Ex Officio.*

APPENDIX C

SUMMARY FACTS SHEETS FOR SELECTED BIOLOGICAL TREATMENT SYSTEMS

LISTING OF APPENDIX C FACT SHEETS *

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2.1.1	Activiated Sludge, Conventional, Diffused Aeration	C-2
2.1.2	Activated Sludge, Conventional Mechanical Aeration	C-4
2.1.3	Activated Sludge, High-Rate Diffused Aeration	C-6
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2.1.5	Activated Sludge, Pure Oxygen Uncovered	C-10
2.1.8	Contact Stabilization, Diffused Aeration	C-12
2.1.10	Extended Aeration	C-14
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2.1.12	Lagoons, Anaerobic	C-13
2.1.13	Lagoons, Facultative	C-20
2.1.15	Oxidation Ditch	C-22
2.2.1	Biological Contactor Rotating	C-24
2.2.6	Trickling Filter, Plastic Media	C-26
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*Drafted by EPA, Municipal Environmental Research Laboratory, Cincinnati, Ohio; currently undergoing peer review. When approved, final copies will be inserted in this document.

DRAFT SEP 1 1983

ACTIVATED SLUDGE, CONVENTIONAL, DIFFUSED AERATION FACT SHEET 2.1.1

DESCRIPTION - Activated sludge is a continuous flow, biological treatment process characterized by a suspension of aerobic microorganisms, maintained in a relatively homogeneous state by the mixing and turbulence induced by aeration. The microorganisms are used to oxidize soluble and colloidal organics to CO_2 and H_2O in the presence of molecular oxygen. The process is generally, but not always, preceded by primary sedimentation. The mixture of microorganisms and wastewater formed in the aeration basins, called mixed liquor, is transferred to gravity clarifiers for liquid-solids separation. The major portion of the microorganisms settling out in the clarifiers is recycled to the aeration basins to be mixed with incoming wastewater, while the excess, which constitutes the waste sludge, is sent to the sludge handling facilities. The rate and concentration of activated sludge returned to the aeration basins determines the mixed liquor suspended solids (MLSS) level developed and maintained in the basins. During the oxidation process, a certain amount of the organic material is synthesized into new cells, some of which then undergoes auto-oxidation (self-oxidation, or endogenous respiration) in the aeration basins, the remainder forming net growth or excess sludge. Oxygen is required in the process to support the oxidation and synthesis reactions. Volatile compounds are driven off to a certain extent in the aeration process. Metals will also be partially removed, with accumulation in the sludge. Activated sludge systems are classified as high rate, conventional, or extended aeration (low rate) based on the organic loading. In the conventional activated sludge plant, the wastewater is commonly aerated for a period of four to eight hours (based on average daily flow) in a plug flow hydraulic mode. Either surface or submerged aeration systems can be employed to transfer oxygen from air to wastewater. Compressors are used to supply air to the submerged systems, normally through a network of diffusers, although newer submerged devices which don't come under the general category of diffusers (e.g., static aerators and jet aerators) are being developed and applied. Diffused air systems may be classified as fine bubble or coarse bubble. Diffusers commonly used in activated sludge service include the following: porous ceramic plates laid in the basin bottom (fine bubble), porous ceramic domes or ceramic or plastic tubes connected to a pipe header and lateral system (fine bubble), tubes covered with synthetic fabric or wound filaments (fine or coarse bubble), and specially designed spargers with multiple openings (coarse bubble).

COMMON MODIFICATIONS - Step aeration; contact stabilization; and complete mix flow regimes. Alum or ferric chloride is sometimes added to the aeration tank for phosphorus removal.

TECHNOLOGY STATUS - Activated sludge is the most versatile and widely used biological process in wastewater treatment.

TYPICAL EQUIPMENT/NO. OF MFRS. - (23, 97) - Equipment normally associated with diffused air, activated sludge systems include the following: air diffusers/19; compressors/44.

APPLICATIONS - Domestic wastewater and biodegradable industrial wastewater. The main advantage of the conventional activated sludge system is the lower initial cost of the system, particularly where a high quality effluent is required. Industrial wastewater (including some "priority pollutants") which is amenable to biological treatment and degradation may be jointly treated with domestic wastewater in a conventional activated sludge system.

LIMITATIONS - Limited BOD_5 loading capacity; poor organic load distribution; required aeration time of four to eight hours; plant upset with extreme variations in hydraulic, organic, and toxic loadings; operational complexity; operating costs: energy consuming mechanical compressors; and diffuser maintenance.

PERFORMANCE (26, 39) -		
	BOD_5 Removal (conventional activated sludge)	85-95 percent
	NH_4-N Removal (non-nitrified systems)	10-20 percent

RESIDUALS GENERATED - The following table illustrates the anticipated increase in excess sludge, volatile suspended solids (VSS) production from the conventional activated sludge process as settled wastewater food-to-microorganism (F/M) loadings increase:

F/M (lb BOD_5/d/lb MLVSS)	Excess VSS (secondary effluent plus waste sludge)
0.3	0.5 lb/lb BOD_5 removed
0.5	0.7 lb/lb BOD_5 removed

DESIGN CRITERIA - (26, 31, 30) - A partial listing of design criteria for the conventional activated sludge process is summarized as follows:

Volumetric loading, lb BOD_5/d/1000 ft^3	25-50
Aeration detention time, h (based on avg. daily flow)	4-8
MLSS, mg/l	1500-3000
F/M, lb BOD_5/d/lb MLVSS	0.25-0.5
Air required, std. ft^3/lb BOD_5 removed	800-1500
Sludge retention time, days	5-10

UNIT PROCESS RELIABILITY (31) - Good.

ENVIRONMENTAL IMPACT - Sludge disposal; odor potential; and energy consumption.

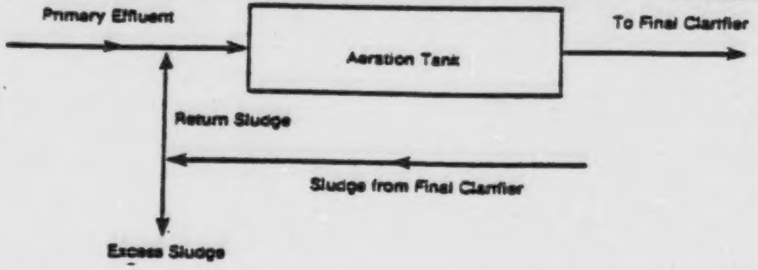
REFERENCES - 23, 26, 28, 30, 31, 39, 97.

DRAFT SEP 1 1983

ACTIVATED SLUDGE, CONVENTIONAL, DIFFUSED AERATION

FACT SHEET 2.1.1

FLOW DIAGRAM -



ENERGY NOTES - Assumptions:

The hydraulic head loss through the aeration tank is negligible. Sludge recycle and sludge wasting pumping energy are a part of clarifier operation.

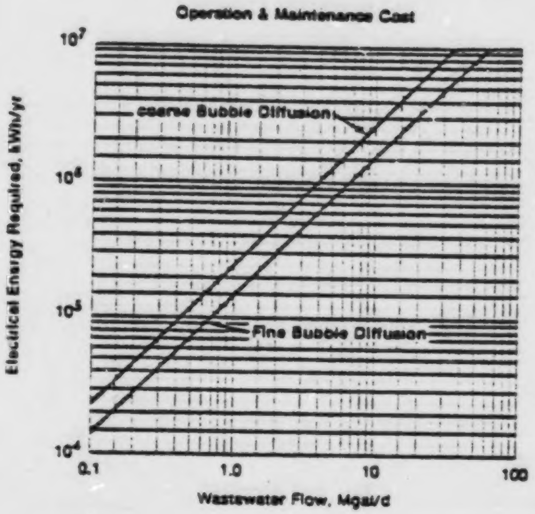
Water quality	Influent (mg/l)	Clarifier Effluent (mg/l)
BOD_5	130	20
Suspended solids	100	20

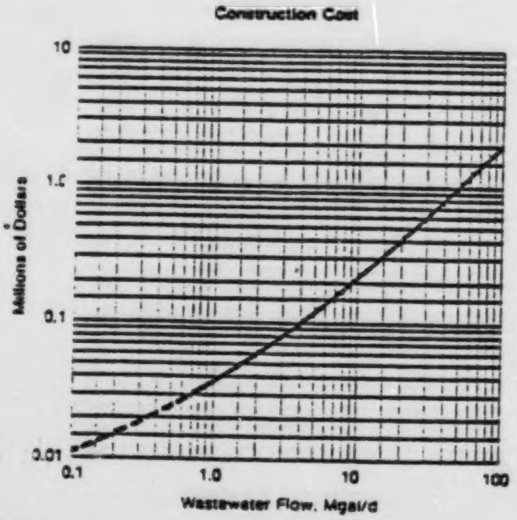
Oxygen Transfer Rate (wire to water) in wastewater for:

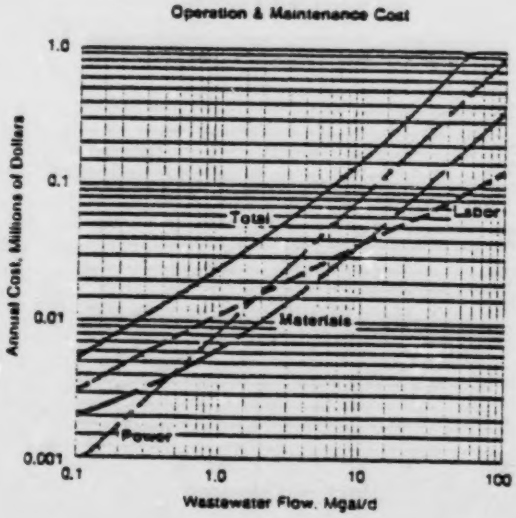
Fine bubble diffusion = 2.5 lb O_2/hph
Coarse bubble diffusion = 1.5 lb O_2/hph
Average oxygen requirement = 1300 lb/d/Mgal/d

COSTS* - Assumptions:

Service life = 40 years. ENR Index = 3875 (October 1982) Construction cost includes aeration basins, air supply and dissolution equipment and piping and blower building. Clarifier and recycle pumps are not included. 1.1 lb O_2 supplied/lb BOD_5 removed. MLVSS = 2100 mg/l. F/M = 0.25 lb BOD_5/d/lb MLVSS. Detention time = 6 hours (based on average daily flow). Volumetric loading = 32 lb BOD_5/d/1,000 ft^3. Power costs are for an average energy requirement of 2.0 lb O_2/hph at $.05/kWh.







REFERENCES - 3, 4.

*To convert construction costs to capital cost see Table A-2.

DRAFT SEP 1 1983

ACTIVATED SLUDGE, CONVENTIONAL, MECHANICAL AERATION

FACT SHEET 2.1.2

DESCRIPTION - The activated sludge system in general, and the conventional activated sludge plant in particular, are described in Fact Sheet 2.1.1. Mechanical aeration methods include the submerged turbine with compressed air spargers (agitator/sparger system) and the surface-type mechanical entrainment aerators. The surface-type aerators entrain atmospheric air by producing a region of intense turbulence at the surface around their periphery. They are designed to pump large quantities of liquid, thus dispersing the entrained air and agitating and mixing the basin contents. The agitator/sparger system consists of a radial-flow turbine located below the mid-depth of the basin, with compressed air supplied to the turbine through a sparger. Volatile compounds are driven off to a certain extent in the aeration process. Metals will also be partially removed, with accumulation in the sludge.

COMMON MODIFICATIONS - In addition to the modifications listed on Fact Sheet 2.1.1 for conventional activated sludge plants, the following mechanical aeration modifications should also be considered. The submerged turbine aeration systems affords a convenient and relatively economical method for upgrading overloaded activated sludge plants. To attain optimum flexibility of oxygen input, the surface aerator can be combined with the submerged turbine aerator. Several manufacturers supply such equipment, with both aerators mounted on the same vertical shaft. Such an arrangement might be advantageous if space limitations require the use of deep aeration basins. In addition, mechanical aerators may be either the floating or fixed installation type.

TECHNOLOGY STATUS - Highly developed and widely used, particularly in the industrial wastewater treatment field. Since 1950, the submerged turbine (widely used in the chemical industry) has come into use for activated sludge aeration.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Equipment normally associated with mechanical aeration conventional activated sludge systems include the following: aerators/30; package treatment plants/21.

APPLICATIONS - See Fact Sheet 2.1.1. Has been used primarily in industrial waste activated sludge treatment plants and is considered an attractive aeration system for very deep basins (with bottom mixers or spargers plus surface aerators), for activated sludges having high oxygen uptake rates, and for high concentrations of MLSS as in aerobic digesters.

LIMITATIONS - Limited BOD loading capacity; poor organic load distribution; required aeration time of four to eight hours; plant upset with extreme variations in hydraulic and organic loadings; operational complexity and the resulting operating costs; energy consuming mechanical aerators; aerator maintenance; and potential for ice formation around surface aerators.

PERFORMANCE -

BOD Removal (conventional activated sludge system)	85 to 95 percent
NH_4-N Removal (non-nitrified systems)	10 to 20 percent

RESIDUALS GENERATED - See Fact Sheet 2.1.1.

DESIGN CRITERIA - A partial listing of design criteria for the mechanically-aerated conventional activated sludge process is summarized as follows:

Volumetric loading, lb BOD_5/d/1000 ft^3	25-50	
Aeration detention time, h (based on average daily flow)	4-8	
MLSS, mg/l	1500-3000	
F/M, lb BOD_5/d/lb MLVSS	0.2-0.5	
Air required, std. ft^3/lb BOD_5 removed	800-1500	(agitator-sparger system only)
Sludge retention time, days	5-10	

Note: The mixing equipment for aeration or oxygen transfer must be sized to keep the solids in uniform suspension at all times. Depending on basin shape and depth, 4000 mg/l of MLSS require about 0.75 to 1.0 hp/1000 ft^3 (0.02 to 0.03 kW/m^3) of basin volume to prevent settling if mechanical aerators are employed. However, the power required to transfer the necessary oxygen will usually equal or exceed this value.

PROCESS RELIABILITY - See Fact Sheet 2.1.1. Reliability of mechanical aeration equipment is dependent on the quality of manufacture and a planned maintenance program.

ENVIRONMENTAL IMPACT - Sludge disposal, aerosol and odor potential, and energy consumption.

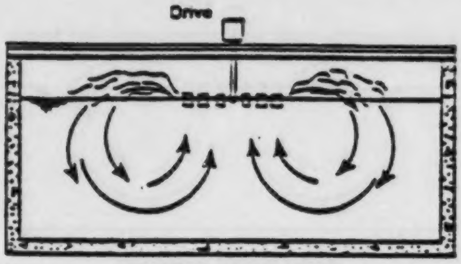
REFERENCES - 23, 26, 28, 30, 31, 39.

DRAFT SEP 1 1983

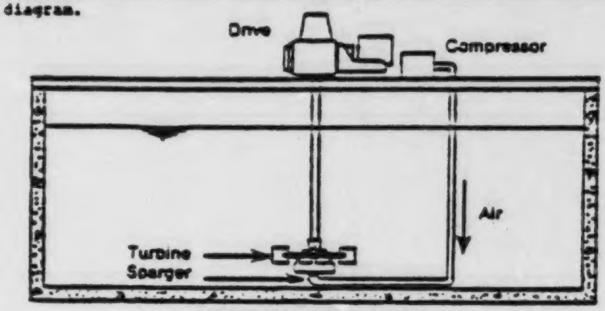
ACTIVATED SLUDGE, CONVENTIONAL, MECHANICAL AERATION

FACT SHEET 2.1.2

FLOW DIAGRAM - See Fact Sheet 2.1.1 for typical flow diagram.



Mechanical Surface Aerator



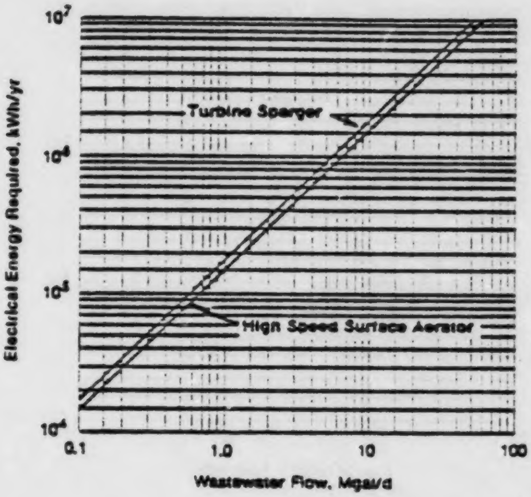
Submerged Turbine Aerator

ENERGY NOTES - Assumptions:

The hydraulic head loss through the aeration tank is negligible. Sludge recycle and sludge wasting pumping energy are a part of clarifier operation.

Water Quality	Influent (mg/l)	Clarifier Effluent (mg/l)
BOD_5	130	20
Suspended Solids	100	20

Assumed Oxygen Transfer Rate = 1.8 lb O_2/hph for high-speed surface aerator and 1.6 lb O_2/hph for turbine sparger (wire to water) in wastewater. Conventional activated sludge oxygen requirement = 1.1 lb O_2/lb BOD_5 removed.

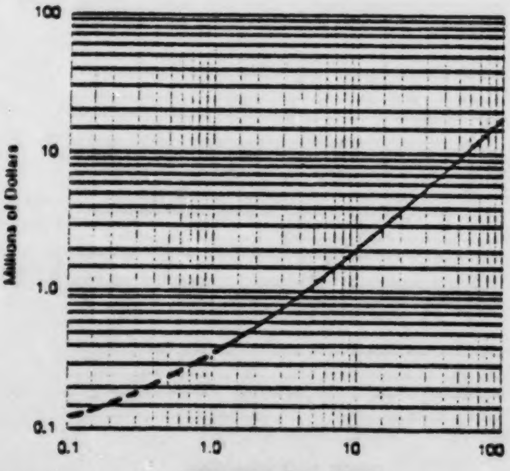


COSTS* -

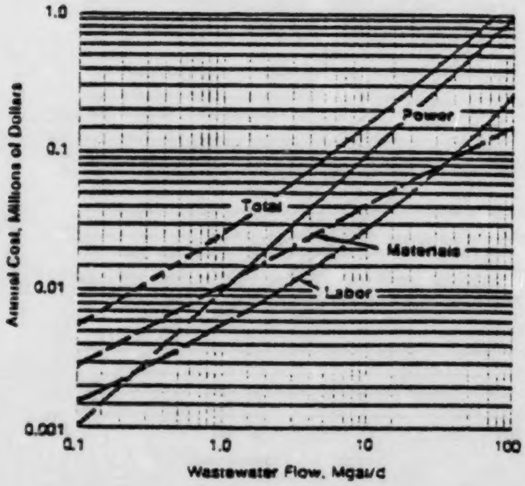
Design Basis: ENR Index = 3875 (October 1982).

1. Construction cost includes aeration basins and surface aerators. Clarifier and recycle pumps are not included.
2. Volumetric loading = 32 lb BOD_5/d/1,000 ft^3.
3. 1.1 lb O_2 supplied/lb BOD_5 removed; Oxygen Transfer Rate = 1.8 lb/hph (high speed surface aerators).
4. MLVSS = 2100 mg/l.
5. F/M = 0.25 lb BOD_5/d/lb MLVSS.
6. Detention time = 6 h (based on average daily flow).

Construction Cost



Operation & Maintenance Cost



REFERENCES - 3, 4.

*To convert construction cost to capital cost see Table A-2.

DRAFT SEP 1 1983

ACTIVATED SLUDGE, HIGH RATE-DIFFUSED AERATION

FACT SHEET 2.1.3

DESCRIPTION - A description of the activated sludge process in general is presented in Fact Sheet 2.1.1. Activated sludge systems have traditionally been classified as high rate, conventional, or extended aeration (low rate) based on organic loading. The term modified aeration has been adopted to apply to those high rate air activated sludge systems with design F/M loadings in the range of 0.75 to 1.5 lb BOD$_5$/d/lb MLVSS. Modified aeration systems are characterized by low MLSS concentrations, short aeration detention times, high volumetric loadings, low air usage rates, and intermediate levels of BOD$_5$ and suspended solids removal efficiencies. Prior to enactment of nationwide secondary treatment regulations, modified aeration was utilized as an independent treatment system for plants where BOD$_5$ removals of 50 to 70 percent would suffice. With present-day treatment requirements, modified aeration no longer qualifies as a "stand-alone" activated sludge option.

Modified aeration basins are normally designed to operate in either complete mix or plug flow hydraulic configurations. Either surface or submerged aeration systems can be employed to transfer oxygen from air to wastewater, although submerged equipment is specified more frequently for this process. Compressors are used to supply air to submerged aeration systems. A description of diffuser alternatives and other submerged aeration devices is presented in Fact Sheet 2.1.1. Volatile compounds are driven off to a certain extent in the aeration process. Metals will also be partially removed; with accumulation in the sludge.

COMMON MODIFICATIONS - Recently, due primarily to rapidly escalating power costs, interest has been expressed in the development of high rate, diffused aeration systems which would produce a high quality secondary effluent. As with modified aeration, aeration detention times would remain low and volumetric loadings high. In contrast to modified aeration systems, high MLSS concentrations would have to be utilized to permit F/M loadings to be maintained at reasonable levels. The key to development of efficient high rate air systems is the availability of submerged aeration equipment that could satisfy the high oxygen demand rates that accompany high MLSS levels and short aeration times. New innovations in fine bubble diffuser and jet aeration technology offer potential for uniting high efficiency oxygen transfer with high rate air activated sludge flow regimes to achieve acceptable secondary treatment as independent "stand alone" processes. Research evaluations and field studies currently underway should provide performance and cost data on this subject in the next several years.

TECHNOLOGY STATUS - Was more widely used in the 1950's and 1960's than it is today because of the less stringent effluent standards in effect during these periods.

TYPICAL EQUIPMENT/NO. OF MFRS. - Equipment normally associated with diffused air, activated sludge systems in general, include the following: air diffusers/19; compressors/44.

APPLICATIONS - See Fact Sheet 2.1.1. Since the early 1970's, employed generally as a pretreatment or roughing process in a two-stage activated sludge system, where the second stage is used for biological nitrification. Alum or one of the iron salts is sometimes added to modified aeration basins preceding second-stage nitrification units for phosphorus removal.

LIMITATIONS - High rate activated sludge alone does not produce an effluent with BOD$_5$ and suspended solids concentrations suitable for discharge into most surface waters in the United States. (Cannot assure that 30 mg/l BOD$_5$ and SS in the final effluent will be achieved).

PERFORMANCE - BOD$_5$ Removal for modified aeration - 50 to 70 percent; for high solids, high rate air system - 85 to 95 percent (tentative).

NH_4-N Removal - 5 to 10 percent.

RESIDUALS GENERATED - One modified air aeration system fed with degritted raw wastewater produced on the average over a two-year period 1.11 lb excess VSS (secondary effluent plus waste sludge)/lb BOD$_5$ removed at an average F/M ratio loading of 1.17 lb BOD$_5$/d/lb MLVSS.

DESIGN CRITERIA (39) - A partial listing of design criteria for the two high rate air activated sludge process options are summarized as follows:

	Modified Aeration	High Solids, High Rate Aeration (tentative)
Volumetric loading, lb BOD$_5$/d/1000 ft^3	50 - 100	50 - 125
MLSS, mg/l	800 - 2000	3000 - 5000
Aeration detention time, hours (based on influent flow)	2 - 3	2 - 4
F/M, lb BOD$_5$/d/lb MLVSS	0.75 - 1.5	0.4 - 0.8
Std ft^3 air/lb BOD$_5$ removed	400 - 800	800 - 1200
lb O_2/lb BOD$_5$ removed	0.4 - 0.7	0.9 - 1.2
Sludge retention time, days	0.75 - 2	2 - 5
Recycle ratio (R)	0.25 - 1.0	0.25 - 0.5
Volatile fraction of MLSS	0.7 - 0.85	0.7 - 0.8

PROCESS RELIABILITY - Requires close operator attention.

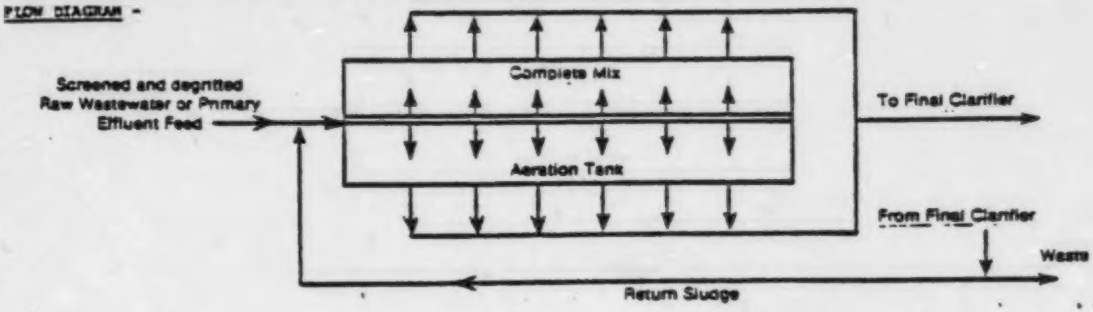
ENVIRONMENTAL IMPACT - See Fact Sheet 2.1.1.

REFERENCES - 23, 26, 31, 39, 263.

ACTIVATED SLUDGE, HIGH RATE, DIFFUSED AERATION

FACT SHEET 2.1.3

FLOW DIAGRAM -

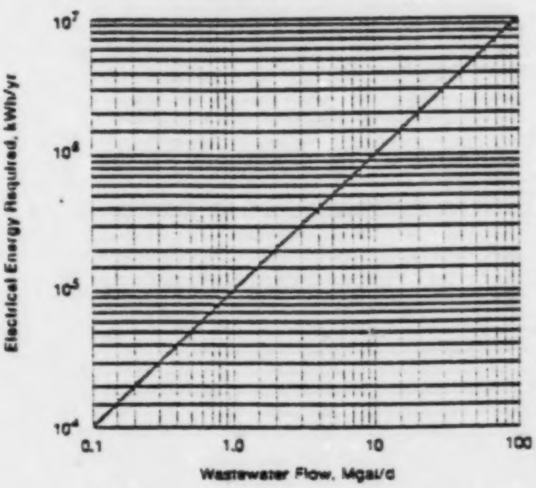

Screened and degritted
Raw Wastewater or Primary
Effluent Feed
Complete Mix
Aeration Tank
To Final Clarifier
From Final Clarifier
Waste Sludge
Return Sludge

ENERGY NOTES - Assumptions: The hydraulic head loss through the aeration tank is negligible. Sludge recycle and sludge wasting pumping energy are a part of clarifier operation. Oxygen Transfer Rate with coarse bubble diffusers = 1.5 lb O_2/hph (wire to water) in wastewater. Other parameters in accordance with cost assumptions.

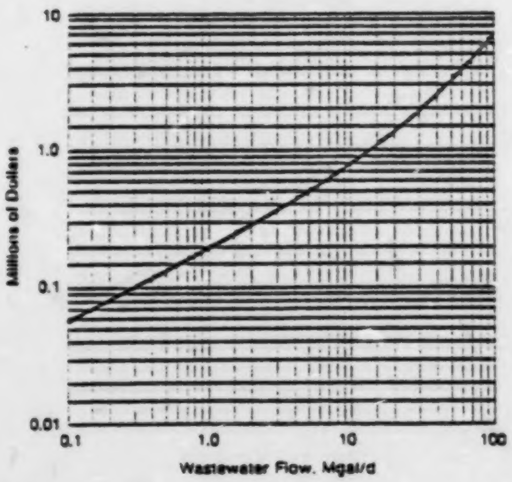
COSTS* - Assumptions: ENR Index = 3875 (October 1982). Construction cost includes aeration basins, air supply equipment and piping, and a blower building. Clarifier and recycle pumps are not included. Basins sized with 50 percent recycle flow. Detention time = 1 h (based on average daily flow). F/M = 1.0 lb BOD_5/d/lb MLVSS. 0.7 lb O_2 applied per lb BOD_5 removed. MLVSS = 1050 mg/l. Service life = 40 years. Costs are for modified aera- tion.

	Influent mg/l	Effluent mg/l
BOD_5	130	40

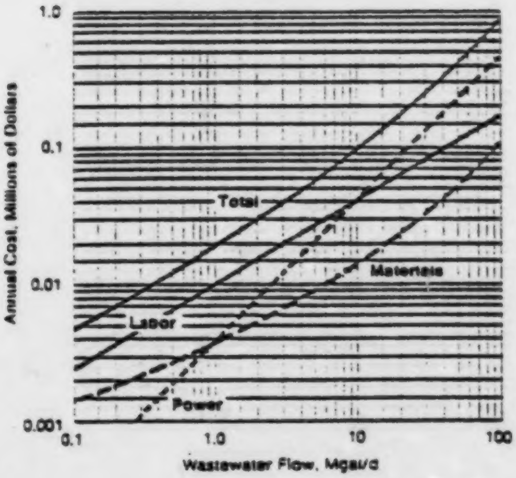
Operation & Maintenance Cost



Construction Cost



Operation & Maintenance Cost



REFERENCES - 3, 4.

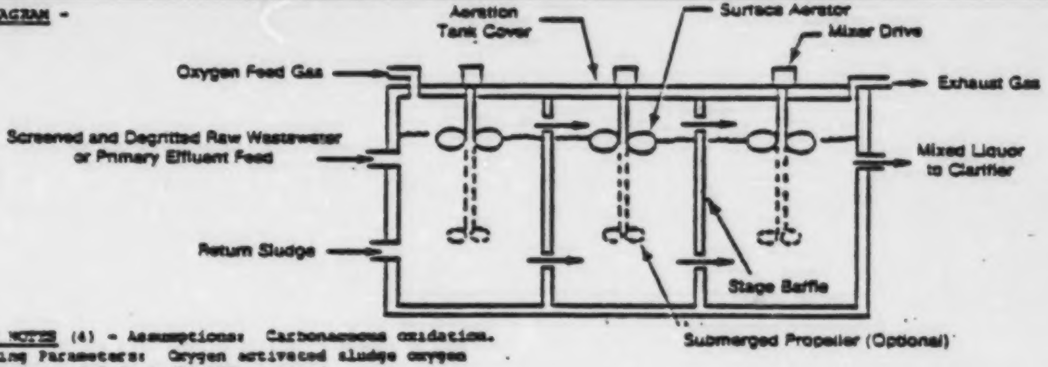
*To convert construction cost to capital cost see Table A-2.

DRAFT SEP 1 1983

ACTIVATED SLUDGE, PURE OXYGEN, COVERED

FACT SHEET 2.1.4

FLOW DIAGRAM -



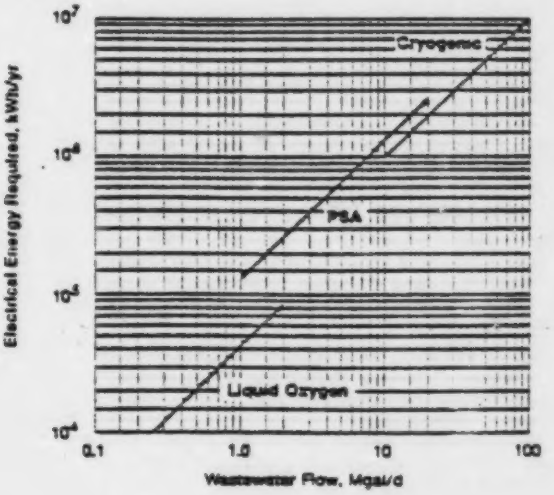
Aeration Tank Cover
Surface Aerator
Mixer Drive
Oxygen Feed Gas
Exhaust Gas
Screened and Degritted Raw Wastewater or Primary Effluent Feed
Mixed Liquor to Clarifier
Return Sludge
Stage Baffle
Submerged Propeller (Optional)

ENERGY NOTES (4) - Assumptions: Carbonaceous oxidation. Operating Parameters: Oxygen activated sludge oxygen requirement = 1.2 lb O_2/lb BOD_5 removed.

Water Quality	Influent (mg/l)	Effluent (mg/l)
BOD_5	130	20

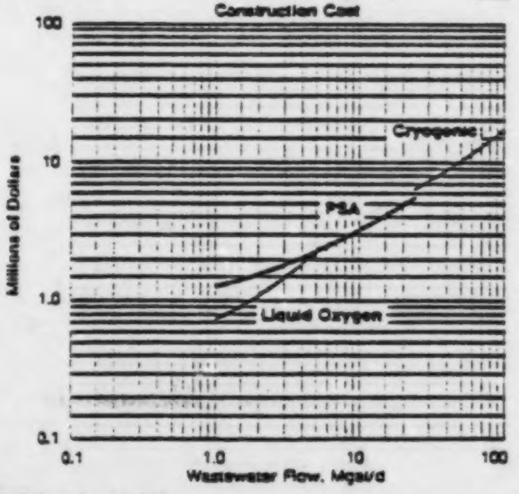
Oxygen Transfer Rate (OTR) includes oxygen production and oxygen dissolution.

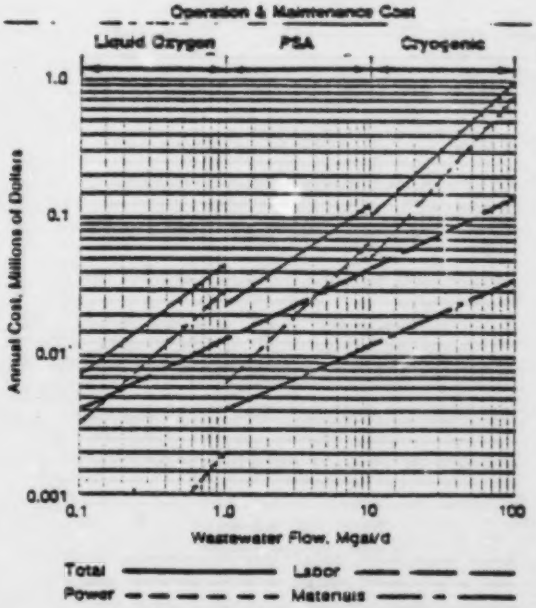
1. With cryogenic oxygen gas generation and surface aerators, OTR = 2.5 lb O_2/hph (wire to water) in wastewater.
2. With pressure swing adsorption (PSA) oxygen gas generation and surface aerators, OTR = 2.0 lb O_2/hph (wire to water) in wastewater.
3. Liquid O_2 supply and surface aerators, OTR = 6.5 lb O_2/hph (wire to water) in wastewater.



COSTS* - Design Basis: October 1982 dollars; ENR Index = 3875. Assumptions: Carbonaceous oxidation.

1. Construction cost includes oxygenation basins, dissolution equipment, oxygen generators and liquid oxygen feed/storage facilities, instrumentation (where applicable), and licensing fees.
2. Oxygen was assumed to be delivered as liquid oxygen for plants from 0.1 to 1 Mgal/d size. For plants from 1.0 to 100 Mgal/d, oxygen was assumed to be generated on-site.
3. 1.2 lb O_2 supplied per lb BOD_5 removed.
4. MLVSS = 3100 mg/l. F/M = 0.5 lb BOD_5/d/lb MLVSS.
5. Volumetric loading = 97 lb BOD_5/d/1000 ft.
6. Detention time = 2 h (based on average daily flow).
7. Electricity at $.03/kWh, labor at $14.80/h, liquid O_2 at $144/t.





REFERENCES - 3, 4, 259.

*To convert construction cost to capital cost, see Table A-2.

ACTIVATED SLUDGE, PURE OXYGEN, COVERED

FACT SHEET 2.1.4

DESCRIPTION - The use of pure oxygen for activated sludge treatment has become competitive with the use of air due to the development of efficient oxygen dissolution systems. The covered oxygen system is a high rate activated sludge system. The main benefits cited for the process include reduced power requirements for dissolving oxygen in the wastewater, reduced aeration tank volume requirements, and improved biokinetics of the activated sludge system. In the covered system, oxygenation is performed in a staged, covered reactor in which oxygen gas is recirculated within the system until it reaches a reduced level of purity and a decreased undissolved mass at which it can no longer be used and is vented to the atmosphere. High-purity oxygen gas (90 to 100 percent volume) enters the first stage of the system and flows concurrently with the wastewater being treated through the oxygenation basin. Pressure under the tank covers is essentially atmospheric, being held at 2 to 4 inches water column, sufficient to maintain oxygen gas feed control and prevent backmixing from stage to stage. Effluent mixed liquor is separated in conventional gravity clarifiers, and the thickened sludge is recycled to the first stage for contact with influent wastewater.

Mass transfer and mixing within each stage are accomplished either with surface aerators or with a submerged-turbine rotating-sparge system. In the first case, mass transfer occurs in the gas space; in the latter, oxygen is sparged into the mixed liquor where mass transfer occurs from the oxygen bubbles to the bulk liquid. In both cases, the mass-transfer process is enhanced by the high oxygen-partial pressure maintained under the tank covers in each stage.

Volatile compounds are driven off to a certain extent in the oxygenation process and removed in the vent gas. Metals may also be expected to be partially removed, with accumulation in the sludge. High purity oxygen may be produced on-site by cryogenic or PSA (Pressure Swing Adsorption) generators, or purchased as liquid oxygen produced off-site and stored at the treatment plant. Cost effectiveness of oxygen source depends upon plant size and process train.

COMMON MODIFICATIONS - Although flexibility is claimed to permit operation in any of the normally used flow regimes, i.e., plug flow, complete mix, step aeration, and contact stabilization, the method of oxygen contact employed favors the plug flow mode. Process may be designed to achieve: optimum carbonaceous oxidation only, combined carbonaceous and nitrogenous oxidation, or optimum nitrogenous oxidation as a separate stage after secondary treatment.

TECHNOLOGY STATUS - Pilot and full scale plant studies since 1969; presently over 100 municipal and industrial plants.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Oxygen activated sludge systems/5; Oxygen generators/1; Liquid oxygen storage tank (for standby and peak load capacity)/1; and aerators/30.

APPLICATIONS - Domestic and biologically degradable industrial wastewaters; upgrading existing air activated sludge plants; new facilities - to reduce construction cost where effective odor control is required, where high effluent dissolved oxygen is required, where reduced quantity and higher concentration of waste sludge is required, and where reduced aeration detention time is required.

LIMITATIONS - Complexity of operation.

PERFORMANCE (46) - Certain pilot test performance data are summarized here:

	Location A	Location B	Location C	Location D
Carbonaceous Oxidation:				
COD, percent removal	77	76	73	80
BOD_5 percent removal	89	95	91	95
Suspended solids, percent removal	89	64	75	76
Nitrogenous Oxidation: NH_4-N percent removals:				
Single stage with carbonaceous oxidation	20% - 90%			
Separate stage nitrification after carbonaceous oxidation	80% - 98%			

RESIDUALS GENERATED (46) - Pilot test systems have generated between 0.42 and 1.0 lb VSS per lb BOD_5 removed.

DESIGN CRITERIA (Carbonaceous BOD_5 Oxidation) -

Volumetric loading, lb BOD_5/d/1000 ft^3	100 to 200
F/M, lb BOD_5/d/lb MLVSS	0.5 to 1.0
Oxygen requirement, lb O_2/lb COD removed	0.6 to 0.8
MLSS, mg/l	3,000 to 6,000
Aeration detention time, hours	1 to 3
Mixed liquor dissolved oxygen, mg/l	4 to 8
Oxygen required, lb O_2/lb BOD_5 removed	0.9 - 1.3

PROCESS RELIABILITY - Complex operation, high level of operator/maintenance attention required.

ENVIRONMENTAL IMPACT - Sludge disposal; energy consumption.

REFERENCES - 22, 26, 28, 46.

DRAFT SEP 1 198

ACTIVATED SLUDGE, PURE OXYGEN, UNCOVERED

FACT SHEET 2.1.5

DESCRIPTION - The use of pure oxygen for activated sludge treatment has become competitive with the use of air due to the development of efficient oxygen dissolution systems. The open tank oxygen system is a high rate activated sludge system. The main benefits cited for the process include reduced power requirements for dissolving oxygen in the wastewater, reduced aeration tank volume requirements, and improved biokinetics of the activated sludge system. In the uncovered system, oxygenation is performed in an open reactor in which extremely fine porous diffusers are utilized to develop small oxygen gas bubbles that are completely dissolved before breaking surface in normal-depth tanks. The basic principles which apply in the transfer of oxygen in conventional diffused air systems also apply to the open tank pure oxygen system.

The pure oxygen open tank system produces ultra-fine bubbles with a correspondingly high gas surface area. These ultra-fine bubbles are of micron size, whereas "fine bubbles" normally produced in diffused air systems are in millimeter sizes. The complete oxygenation system is composed of an oxygen dissolution system comprised of rotating diffusers; a source of high-purity oxygen gas (normally, an on-site oxygen generator); and an oxygen control system which balances oxygen supply with oxygen demand through use of basin-located dissolved oxygen probes and control valves. High purity oxygen may be produced by cryogenic or PSA (Pressure Swing Adsorption) generators, or purchased as liquid oxygen produced off-site and stored at the treatment plant. Selection of cost effective oxygen source depends upon plant size and treatment train.

The influent to the system enters the oxygenation tank and is mixed with return activated sludge. The mixed liquor is continuously and thoroughly mixed using low energy mechanical agitation deep in the mixed liquor. Mixing is produced by radial turbine impellers located on both surfaces (top and bottom) of the rotating diffusion discs. Pure oxygen gas in the form of micron-size bubbles is simultaneously introduced into the tank to accomplish mass oxygen transfer. The rotating diffuser is a gear-driven disc-shaped diffusion device equipped with a porous medium to assist in the diffusion process. As the diffuser rotates at constant speed in the mixed liquor, hydraulic shear wipes bubbles from the medium before they have an opportunity to coalesce and enlarge.

COMMON MODIFICATIONS - Operation in any of the normally-used flow regimes, i.e., plug flow, complete mix, step aeration, and contact stabilization, can be used as conditions dictate since the method of oxygen contact employed does not favor one particular operating mode. System may be designed to optimize carbonaceous (BOD_5) oxidation, combined carbonaceous (BOD_5) and nitrogenous (NOD) oxidation as a single stage, or nitrogenous oxidation as a separate stage after secondary treatment.

TECHNOLOGY STATUS - Recently developed; supplied under proprietary status.

APPLICATIONS - Domestic and biologically degradable industrial wastewaters; plant flows greater than 1 Mgal/d; upgrading existing air activated sludge plants; new facilities - to reduce construction cost where high effluent dissolved oxygen is required, where reduced quantity and higher concentration of waste sludge is required, and where reduced aeration detention time is required.

LIMITATIONS - Complexity of operation.

PERFORMANCE - Removal efficiencies of various pollutants are similar to those of activated sludge and vary with mode of operation, aeration detention time, and character of influent wastewater. Examples of operational and pilot test data have demonstrated the following removals:

Carbonaceous Oxidation:	
BOD_5	75-95%
COD	60-85%
SS	60-90%
Nitrogenous Oxidation:	
Single stage nitrification, NH_4-N	20-90%
Separate stage nitrification after carbonaceous oxidation, NH_4-N	80-98%

RESIDUALS GENERATED - Between 0.42 and 1.00 lb VSS per lb BOD_5 removed.

DESIGN CRITERIA -

Volumetric Loading	100 to 200 lb BOD_5/d/1000 ft^3
F/M	0.5 to 1.0 lb BOD_5/d/lb MLVSS
Oxygen requirement,	
lb O_2/lb BOD_5 removed	0.9-1.3
lb O_2/lb COD removed	0.6 to 0.8
Aeration Detention Time	1 to 3 h (based on avg. daily flow)
Mixed Liquor D.O.	2 to 6 mg/l
MLSS	3,000 to 6,000 mg/l

PROCESS RELIABILITY - Not yet fully established.

ENVIRONMENTAL IMPACT - Sludge disposal; odor potential; and energy consumption.

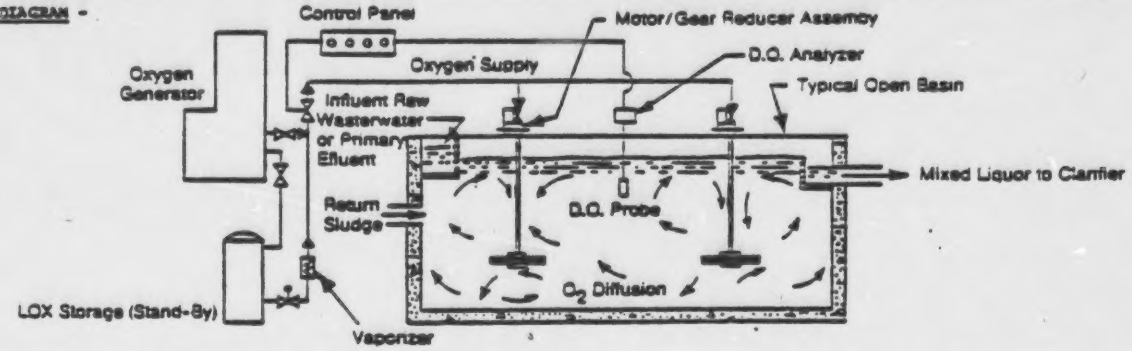
REFERENCES - 26, 185, 186.

DRAFT SEP 1 198

ACTIVATED SLUDGE, PURE OXYGEN, UNCOVERED

FACT SHEET 2.1.5

FLOW DIAGRAM -



Control Panel
Motor/Gear Reducer Assembly
D.O. Analyzer
Oxygen Generator
Oxygen Supply
Typical Open Basin
Influent Raw Wastewater or Primary Effluent
Mixed Liquor to Clarifier
Return Sludge
D.O. Probe
O2 Diffusion
LOX Storage (Stand-By)
Vaporizer

ENERGY NOTES (4) - Assumptions: Carbonaceous oxidation.

Operating Parameters: Oxygen activated sludge oxygen requirement = 1.2 lb O_2/lb BOD_5 removed.

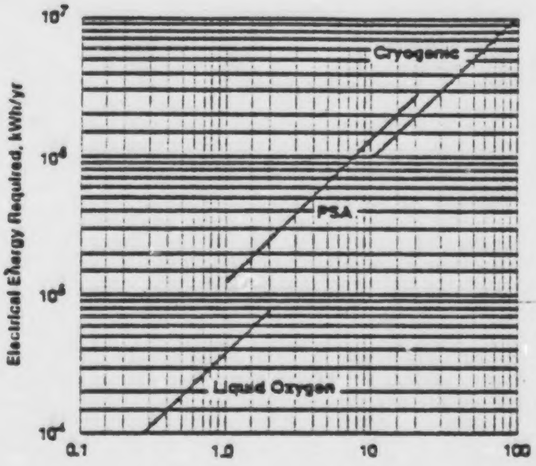
Water Quality	Influent (mg/l)	Effluent (mg/l)
BOD_5	130	20

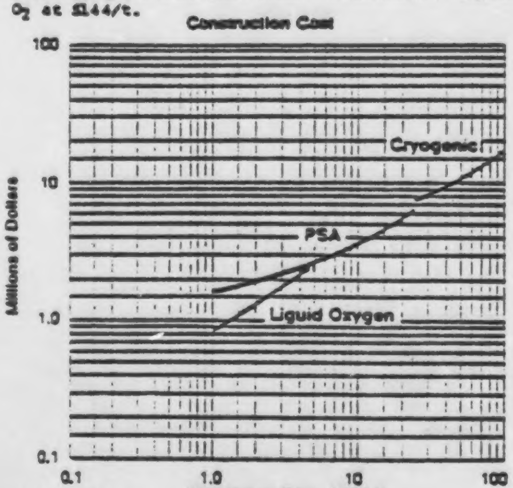
Oxygen Transfer Rate (OTR) includes oxygen production and oxygen dissolution.

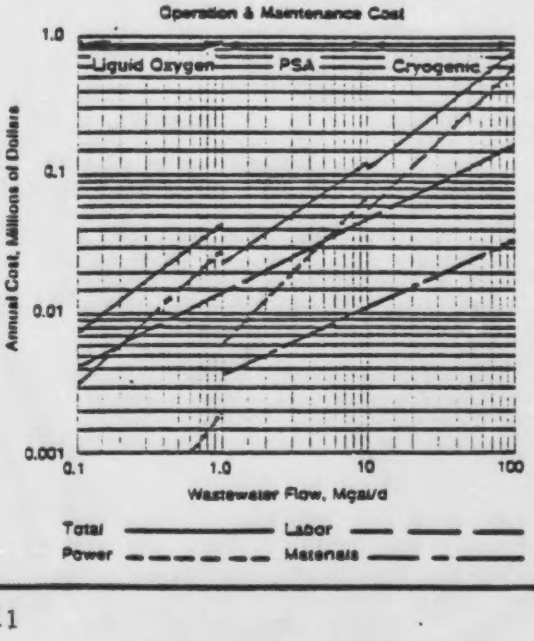
1. With cryogenic oxygen gas generation and surface aerators. OTR = 2.5 lb O_2/hph (wire to water) in wastewater.
2. With pressure swing adsorption (PSA) oxygen gas generation and surface aerators. OTR = 2.0 lb O_2/hph (wire to water) in wastewater.
3. Liquid O_2 supply and surface aerators. OTR = 6.5 lb O_2/hph (wire to water) in wastewater.

COSTS* - Design Basis: October 1982 dollars; ENR Index = 3875. Assumptions: Carbonaceous oxidation.

1. Construction cost includes oxygenation basins, dissolution equipment, oxygen generators and liquid oxygen feed/storage facilities, instrumentation (where applicable), and licensing fees.
2. Oxygen was assumed to be delivered as liquid oxygen for plants from 0.1 to 1 Mgal/d size. For plants from 1.0 to 100 Mgal/d, oxygen was assumed to be generated on-site.
3. 1.2 lb O_2 supplied per lb BOD_5 removed.
4. MLVSS = 3100 mg/l. F/M = 0.5 lb BOD_5/d/lb MLVSS.
5. Volumetric loading = 97 lb BOD_5/d/1000 ft.
6. Detention time = 2 h (based on average daily flow).
7. Electricity at $.05/kWh, labor at $14.80/h, liquid O_2 at $144/t.







REFERENCES - 3, 4, 239.

*To convert construction cost to capital cost, see Table A-2.

DRAFT SEP 1 1983

CONTACT STABILIZATION, DIFFUSED AERATION

FACT SHEET 2.1.8

DESCRIPTION - Contact stabilization is a modification of the activated sludge process (described more completely in Fact Sheet 2.1.1). In this modification, the adsorptive capacity of the floc is utilized in the contact tank to adsorb suspended, colloidal, and some dissolved organics. The hydraulic detention time in the contact tank is only 30 to 60 minutes (based on average daily flow). After the biological sludge is separated from the wastewater in the secondary clarifier, the concentrated sludge is separately aerated in the stabilization tank with a detention time of 2 to 6 hours (based on sludge recycle flow). The adsorbed organics undergo oxidation in the stabilization tank, endogenous respiration will occur, along with a concomitant decrease in excess biological sludge production. Following stabilization, the reaerated sludge is mixed with incoming wastewater in the contact tank and the cycle starts anew. Volatile compounds are driven off to a certain extent by aeration in the contact and stabilization tanks. Metals will also be partially removed, with accumulation in the sludge.

This process requires smaller total aeration volume than the conventional activated sludge process. It also can handle greater organic shock and toxic loadings because of the biological buffering capacity of the stabilization tank and the fact that at any given time the majority of the activated sludge is isolated from the main stream of the plant flow. Generally, the total aeration basin volume (contact plus stabilization basins) is only 50-75 percent of that required in the conventional activated sludge system. A description of diffused aeration techniques is presented in Fact Sheet 2.1.1.

COMMON MODIFICATIONS - Used in a package treatment plant with clarification and chlorination facilities in one vessel. Other modifications include raw wastewater feed to aeration tank; flow equalization; integral aerobic digester.

TECHNOLOGY STATUS - Contact stabilization has evolved as an outgrowth of activated sludge technology since 1950 and seen common usage in package plants and some usage for on-site constructed plants.

TYPICAL EQUIPMENT/NO. OF MFRS. - Air diffusers/19; compressors/44; package treatment plants/21.

APPLICATIONS - Wastewaters that have an appreciable amount of BOD_5 in the form of suspended and colloidal solids; upgrading of an existing, hydraulically overloaded conventional activated sludge plant; new installations, to take advantage of low aeration volume requirements; where the plant might be subject to shock organic or toxic loadings; where larger, more uniform flow conditions are anticipated (or if the flows to the plant have been equalized).

LIMITATIONS - It is unlikely that effluent standards can be met using contact stabilization in plants smaller than 50,000 gal/d without some prior flow equalization. Other limitations include operational complexity, high operating costs, high energy consumption and high diffuser maintenance. As the fraction of soluble BOD_5 in the influent wastewater increases, the required total aeration volume of the contact stabilization process approaches that of the conventional process.

PERFORMANCE -

BOD_5 Removal	80 to 95 percent
NH_4-N Removal	10 to 20 percent

RESIDUALS GENERATED - See Fact Sheet 2.1.1.

DESIGN CRITERIA (39) - A partial listing of design criteria for the contact stabilization process is summarized as follows:

F/M, lb BOD_5/d/lb MLVSS	0.2 to 0.6
Volumetric loading, lb BOD_5/d/1,000 ft^3	30 to 50 (based on contact and stabilization volume)
MLSS, mg/l	1,000 to 2,500, contact tank; 4,000 to 10,000, stabilization tank
Aeration time, h	0.5 to 1.0, contact tank (based on average daily flow) 2 to 6, stabilization basin (based on sludge recycle flow)
Sludge retention time, days	5 to 10
Recycle ratio (R)	0.25 to 1.0
Std. ft^3 air/lb BOD_5 removed	800 to 2,100
lb O_2/lb BOD_5 removed	0.7 to 1.0
Volatile fraction of MLSS	0.6 to 0.8

PROCESS RELIABILITY - Requires close operator attention.

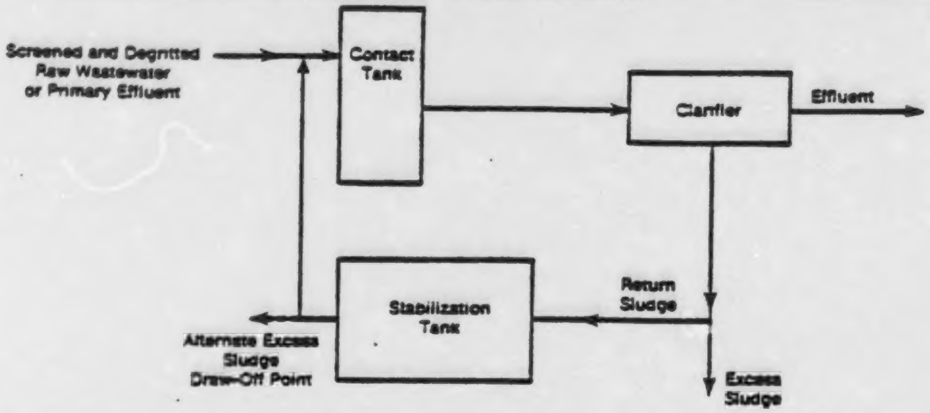
ENVIRONMENTAL IMPACT - See Fact Sheet 2.1.1.

REFERENCES - 23, 26, 31, 39.

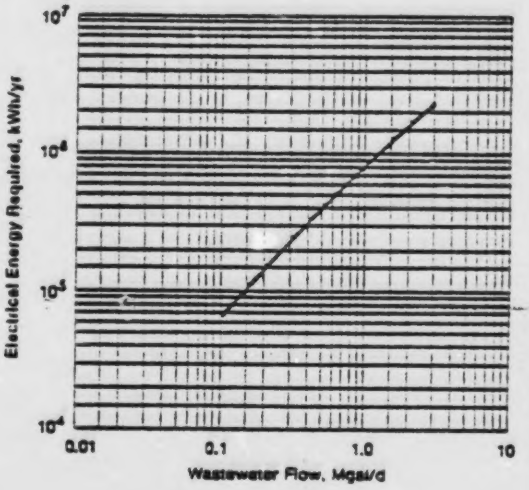
CONTACT STABILIZATION, DIFFUSED AERATION

FACT SHEET 2.1.8

FLOW DIAGRAM -


Screened and Degritted
Raw Wastewater
or Primary Effluent
Contact Tank
Clarifier
Effluent
Stabilization Tank
Return Sludge
Alternate Excess Sludge Draw-Off Point
Excess Sludge

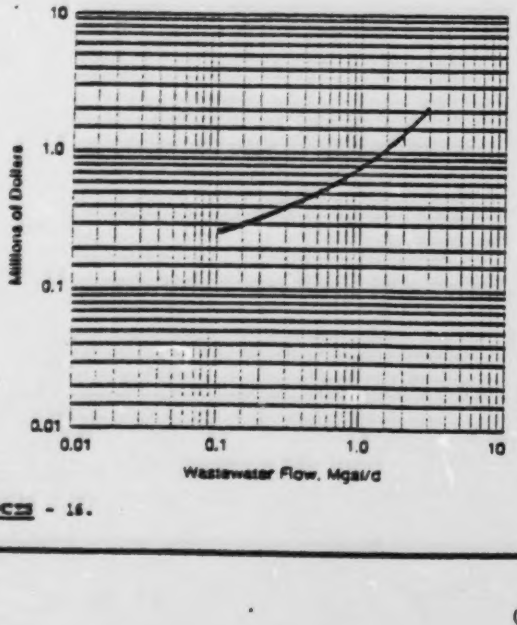
ENERGY NOTES - Assumptions: Air requirements are based on 2100 ft^3/lb BOD$_5$ removed (2 lb BOD$_5$/1000 gal/d). Positive displacement blowers with 100% standby are provided. Electricity = $.05/kWh. Includes energy requirements for entire package plant.



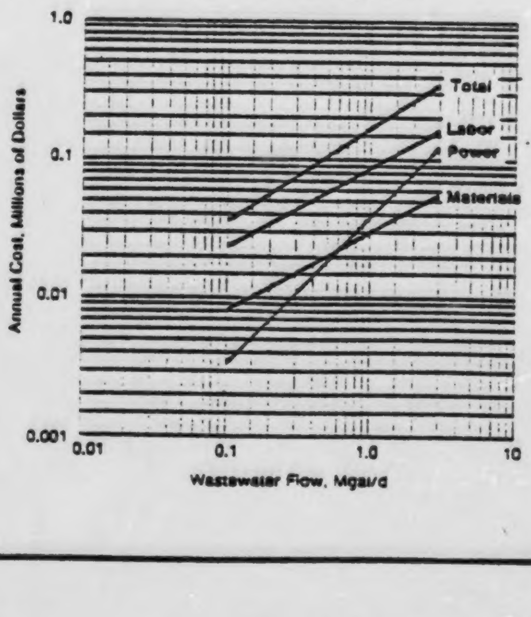
Costs* - Assumptions: Costs are in October 1982 dollars; ENR Index = 3875.

1. Construction cost is for package plants and includes tankage and equipment in place for aeration chambers, chlorination equipment, clarification and sludge stabilization. Costs include concrete and yardwork, 15% contingency, electrical and instrumentation, and contractor's overhead and profit at 25% of equipment costs but exclude land, engineering, legal or financing during construction.
2. O&M costs are based on a labor rate of $12.00/h, including fringe benefits, with 7 d/wk staffing and electricity at $.05/kWh. Maintenance materials include chlorine.

Construction Cost



Operation & Maintenance Cost



REFERENCES - 16.

EXTENDED AERATION, MECHANICAL AND DIFFUSED AERATION

FACT SHEET 2.1.10

DESCRIPTION - Extended aeration is the "low rate" modification of the activated sludge process. The F/M loading is in the range of 0.05 to 0.15 lb BOD_5/d/lb MLVSS, and the detention time is about 24 hours. Primary clarification is rarely used. The extended aeration system operates in the endogenous respiration phase of the bacterial growth cycle, because of the low BOD_5 loading. The organisms are starved and forced to undergo partial auto-oxidation. Volatile compounds are driven off to a certain extent in the aeration process. Metals will also be partially removed, with accumulation in the sludge.

In the complete mix version of the extended aeration process, all portions of the aeration basin are essentially homogeneous, resulting in a uniform oxygen demand throughout the aeration tank. This condition can be accomplished fairly simply in a symmetrical (square or circular) basin with a simple mechanical aerator or by diffused aeration. The raw wastewater and return sludge enter at a point (e.g., under a mechanical aerator) where they are quickly dispersed throughout the basin. In rectangular basins with mechanical aerators or diffused air, the incoming waste and return sludge are distributed along one side of the basin and the mixed liquor is withdrawn from the opposite side.

COMMON MODIFICATIONS - Step aeration, contact stabilization, and plug flow regimes. Alum or ferric chloride is sometimes added to the aeration tank for phosphorus removal.

TECHNOLOGY STATUS - Extended aeration plants have evolved since the latter part of the 1940's. Pre-engineered, package plants have been widely utilized for this process.

TYPICAL EQUIPMENT/NO. OF MFRS. - Aerators/30; package treatment plants/21; air diffusers/19; compressors/44.

APPLICATIONS - Commonly flows of less than 50 000 gal/d; emergency or temporary treatment needs; and biodegradable wastewater.

LIMITATIONS - High power costs, operation co[illegible], and capital costs (for large permanent installations where the pre-engineered plants would not be appropriate).

PERFORMANCE -

BOD_5 Removal	85-95%
NH_4-N Removal (Nitrification)	50-90%

RESIDUALS GENERATED - Because of the low F/M loadings and long hydraulic detention times employed, excess sludge production for the extended aeration process (and the closely related oxidation ditch process) is the lowest of any of the activated sludge process alternatives, generally in the range of 0.15 to 0.3 lb excess total suspended solids/lb BOD_5 removed.

DESIGN CRITERIA (39) - A partial listing of design criteria for the extended aeration modification of the activated sludge process is summarized as follows:

Volumetric loading, lb BOD_5/d/1,000 ft^3	5 to 10
MLSS, mg/l	3,000 to 6,000
F/M, lb BOD_5/d/lb MLVSS	0.5 to 0.15
Aeration detention time, hours (based on average daily flow)	18 to 36
Standard ft^3 air/lb BOD_5 applied	3,000 to 4,000
lb O_2/lb BOD_5 applied	2.0 to 2.5 (based on 1.5 lb O_2/lb BOD_5 removed + 4.6 lb O_2/lb NH_4-N removed)
Sludge retention time, days	20 to 40
Recycle ratio (R)	0.75 to 1.5
Volatile fraction of MLSS	0.6 to 0.7

PROCESS RELIABILITY - Good.

ENVIRONMENTAL IMPACT - See Fact Sheet 2.1.1.

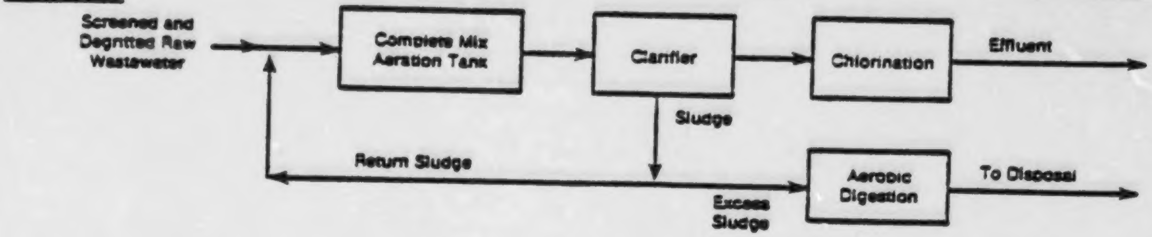
REFERENCES - 23, 26, 31, 39.

DRAFT SEP 1 1982

EXTENDED AERATION, MECHANICAL AND DIFFUSED AERATION

FACT SHEET 2.1.10

FLOW DIAGRAM -


Screened and Degritted Raw Wastewater
Complete Mix Aeration Tank
Clarifier
Chlorination
Effluent
Sludge
Return Sludge
Excess Sludge
Aerobic Digestion
To Disposal

ENERGY NOTES - Assumptions: The hydraulic head loss through the aeration tank is negligible. Sludge recycle and sludge wasting pumping energy are included.

Water Quality	Influent (mg/l)	Effluent (mg/l)
BOD_5	210	20
Suspended Solids	230	20
NH_4-N	20	1

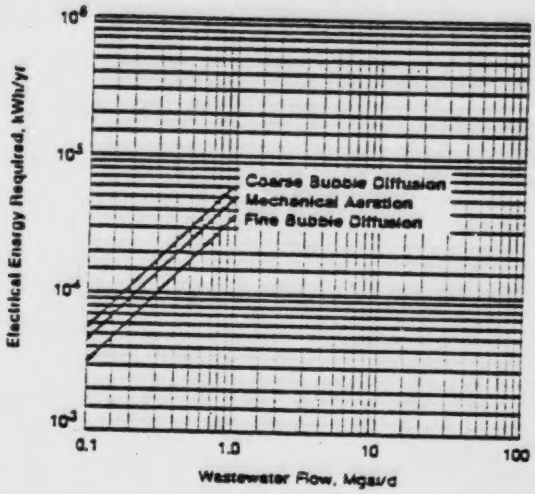
Oxygen Transfer Rate (wire to water) in wastewater for:

Mechanical Aeration = 1.8 lb O_2/hph
Diffused Aeration
Coarse Bubble Diffusion = 1.5 lb O_2/hph
Fine Bubble Diffusion = 2.5 lb O_2/hph

Oxygen Requirement:

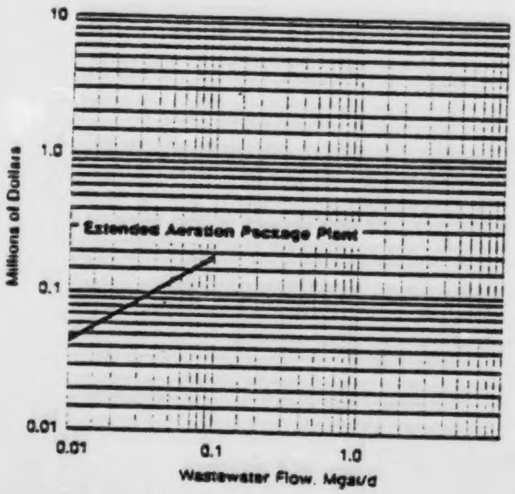
1.5 lb O_2/lb BOD_5 removed plus 4.6 lb O_2/lb of NH_4-N removed

Construction Cost

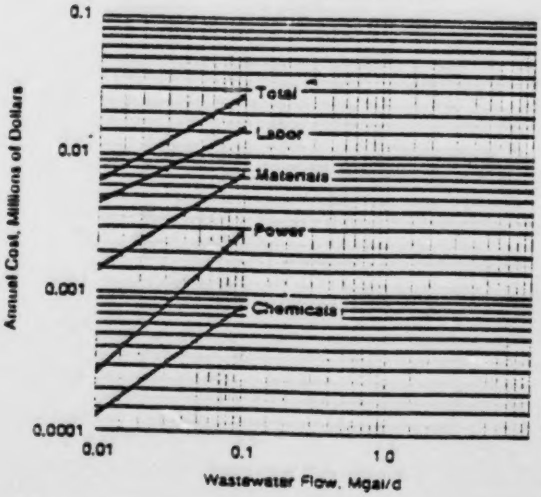


COSTS* - Assumptions: Construction cost includes comminutor, aeration basin, clarifier, chlorine contact chamber, aerobic digester, chlorine feed facility, building, fencing for extended aeration package plants between 0.01 and 0.1 Mgal/d. Detention time: 24 hours (based on average daily flow). ENR Index = 3875 (October 1982). Annual power costs based on coarse bubble diffuser.

Construction Cost



Operation & Maintenance Cost



REFERENCES - 3, 4.

*To convert construction cost to capital cost see Table A-2.

LAGOONS, AERATED

FACT SHEET 2.1.11

DESCRIPTION - Aerated lagoons are medium-depth basins designed for the biological treatment of wastewater on a continuous basis. In contrast to stabilization ponds, which obtain oxygen from photosynthesis and surface reaeration, they employ aeration devices which supply supplemental oxygen to the system. The aeration devices may be mechanical (i.e., surface aerator), or diffused air systems. Surface aerators are divided into two types: cage aerators and the more common turbine and vertical shaft aerators. The many diffused air systems utilized in lagoons consist of plastic pipes supported near the bottom of the cells with regularly spaced sparger holes drilled in the tops of the pipes. Because aerated lagoons are normally designed to achieve partial mixing only, aerobic-anaerobic stratification will occur, and a large fraction of the incoming solids and a large fraction of the biological solids produced from waste conversion settle to the bottom of the lagoon cells. As the solids begin to build up, a portion will undergo anaerobic decomposition. Volatile toxics can potentially be removed by the aeration process, and incidental removal of other toxics can be expected to be similar to an activated sludge system. Several smaller aerated lagoon cells in series are more effective than one large cell. Tapering aeration intensity downward in the direction of flow promotes settling out of solids in the last cell. A non-aerated polishing cell following the last aerated cell is an optional, but recommended, design technique to enhance suspended soils removal prior to discharge.

COMMON MODIFICATIONS - The lagoons may be lined with concrete or an impervious flexible lining, depending on soil conditions and environmental regulations. Use of various types of aeration. When high-intensity aeration produces completely mixed (all aerobic) conditions, a final settling tank is required. Solids are recycled to maintain about 800 mg/l MLVSS in this mode.

TECHNOLOGY STATUS - While not as widely used when compared with the large number of stabilization ponds in common use throughout the U.S., it has been fully demonstrated, and used for years.

APPLICATIONS - Used for domestic and industrial wastewater of low and medium strength. Commonly used where land is inexpensive and costs and operational control are to be minimized. It is relatively simple to upgrade existing oxidation ponds, lagoons, and natural bodies of water to this type of treatment. Aeration increases the oxidation capacity of the pond and is useful in overloaded ponds that generate odors. Useful when supplemental oxygen requirements are high or when the requirements are either seasonal or itermittent.

LIMITATIONS - In very cold climates aerated lagoons may experience reduced biological activity and treatment efficiency, and the formation of ice.

TYPICAL EQUIPMENT/NO. OF MFRS. - (23) - Lining systems/6; aerators/30; hydraulic controls/29

PERFORMANCE -

	Influent	% Removed
BOD	200 - 500 mg/l	60 - 90
COD	-	70 - 90
TSS	200 - 500 mg/l	70 - 90

RESIDUALS - Settled solids on pond bottom may require clean-out every 10 to 20 years, or possibly more often if a polishing pond is used behind the aerated pond.

DESIGN CRITERIA (12, 67) -

Operation: One or more aerated cells, followed by a settling (unaerated) cell
Detention time: 3 to 10 days
Depth, ft: 6 to 20
pH: 6.5 to 8.0

Water Temperature range: 0 to 40°C
Optimum Water Temperature: 20°C
Oxygen requirement: 0.7 to 1.4 times the amount of BOD_5 removed
Organic Loading: 10 to 300 lb BOD_5/acre/d

Energy Requirements:

For aeration: 6 to 10 hp/million gallons capacity
To maintain all solids in suspension: 60 to 100 hp/million gallons capacity
To maintain some solids in suspension: 30 to 40 hp/million gallons capacity

PROCESS RELIABILITY - The service life of a lagoon is estimated at 30 years or more. The reliability of equipment and the process is high. Little operator expertise is required.

ENVIRONMENTAL IMPACTS - There is opportunity for volatile organic material and pathogens in aerated lagoons to enter the air as with any aerated wastewater treatment process. This opportunity depends on air/water contact afforded by the aeration system. There is potential for seepage of wastewater into groundwater unless a lagoon is lined. Compared to other secondary treatment processes, aerated lagoons generate less solid residues.

TOXICS - Volatile toxics will be removed, and incidental removal of other toxics can be expected to be similar to an activated sludge system.

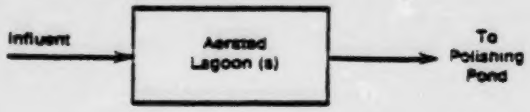
REFERENCES - 7, 12, 13, 18, 23, 67.

DRAFT SEP 1 1983

LAGOONS, AERATED

FACT SHEET 2.1.11

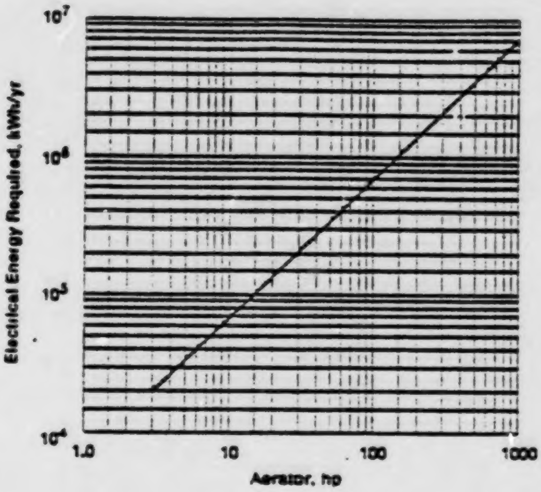
FLOW DIAGRAM -



ENERGY NOTES (4) -

Low speed mechanical surface aerators; motor efficiency = 90%; aerator efficiency = 1.8 lb O_2/hph (wire to water); head loss negligible. Type of energy required: electrical.

For additional information on energy requirements and transfer efficiency of selected aeration devices, refer to Table D-1.



COSTS* (3) - Assumptions:

1. Service life, 30 years; ENR Index = 3875 (October 1982).
2. Theoretical detention time = 7 d; 15-ft water depth; floating mechanical aerators.
3. Horsepower required = 36 hp/Mgal of capacity; power at $0.05/kWh.
4. Construction cost includes excavation, embankment, and seeding of lagoon/slopes (3 cells); service road and fencing; riprap embankment protection; hydraulic control works; aeration equipment and electrical equipment.

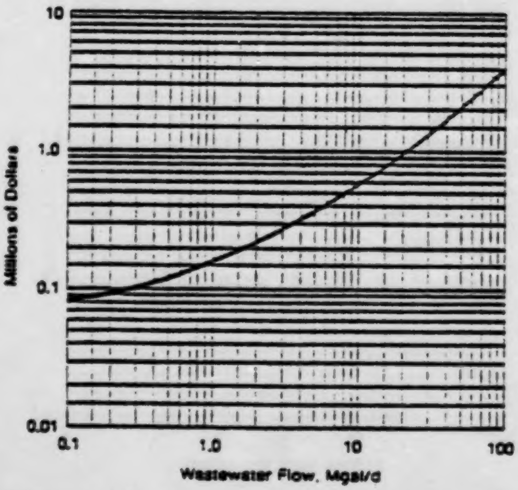
Wastewater Characteristics:

	In	Out
BOD_5, mg/l	210	25
COD, mg/l	400	50
TSS, mg/l	230	40
Total-P, mg/l	11	8
NH_3-N, mg/l	20	18

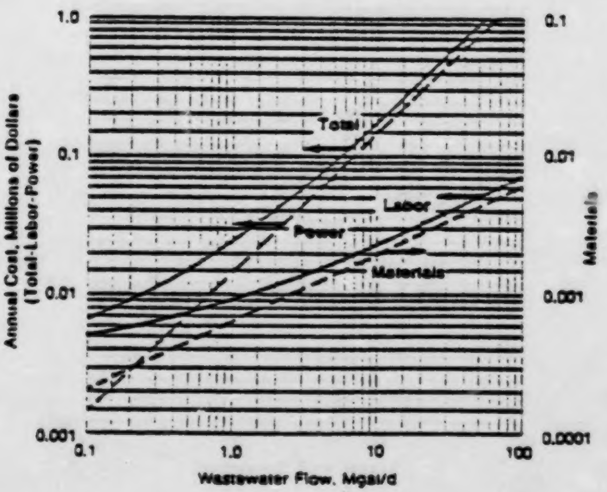
To adjust construction cost for detention time other than above, enter curve at effective flow (Q_E)

$$Q_E = Q_{DESIGN} \times \frac{\text{New Design Detention Time}}{7\ \text{days}}$$

Construction Cost



Operation & Maintenance Cost



REFERENCES - 3, 4.

*To convert construction cost to capital cost see Table A-2.

LAGOONS, ANAEROBIC

FACT SHEET 2.1.12

DESCRIPTION - Anaerobic lagoons are relatively deep (up to 20 ft) ponds with steep sidewalls in which anaerobic conditions are maintained by keeping loading so high that complete deoxygenation is prevalent. Although some oxygenation is possible in a shallow surface zone, once greases form an impervious surface layer, complete anaerobic conditions develop. Treatment or stabilization results from thermophilic anaerobic digestion of organic wastes. The treatment process is analogous to that occurring in single stage untreated anaerobic digestion of sludge in which acid forming bacteria break down organics. The resultant acids are then converted to carbon dioxide, methane, cells and other end products.

In the typical anaerobic lagoon, raw wastewater enters near the bottom of the pond (often at the center) and mixes with the active microbial mass in the sludge blanket, which is usually about 6 ft deep. The discharge is located near one of the sides of the pond, submerged below the liquid surface. Excess undigested grease floats to the top, forming a heat retaining and relatively airtight cover. Wastewater flow equalization and heating are generally not practiced. Excess sludge is washed out with the effluent. Recirculation of waste sludge is not required.

Anaerobic lagoons are capable of providing treatment of high strength wastewaters and are resistant to shock loads.

COMMON MODIFICATIONS - Anaerobic lagoons are customarily contained within earthen dikes. Depending on soil characteristics, lining with various impervious materials such as rubber, plastic or clay may be necessary. Pond geometry may vary, but surface area to volume ratios are minimized to enhance heat retention.

TECHNOLOGY STATUS - Although anaerobic processes are common for sludge digestion, anaerobic lagoons for wastewater treatment have found only limited application. The process is well demonstrated for stabilization of highly concentrated organic wastes.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Lining systems/6; hydraulic controls/29

APPLICATIONS - Typically used in series with aerobic or facultative lagoons. Anaerobic lagoons are effective as roughing units prior to aerobic treatment of high strength wastes.

LIMITATIONS - May generate odors. Requires relatively large land area. For efficient operation, water temperatures above 75°F should be maintained.

PERFORMANCE - BOD_5 removals of 50 to 70 percent are achievable depending on loading and temperature conditions. TSS concentrations may increase, especially if the influent BOD_5 is primarily dissolved. Generally does not produce an effluent suitable for direct discharge to receiving waters.

RESIDUALS GENERATED - In anaerobic lagoons excess sludge is usually washed out in the effluent. Since anaerobic lagoons are often used for preliminary treatment recirculation or removal of sludge not generally required.

CHEMICALS REQUIRED - Nutrients as needed to make up deficiencies in raw wastewater. No other chemicals required.

DESIGN CRITERIA -

Operation: Parallel or series
Detention Time: 20 to 50 d
Depth, ft: 8 to 20
pH: 6.8 to 7.2
Water Temperature Range: 35 to 120°F
Optimum Water Temperature: 86°F
Organic loading: 200 to 2200 lb BOD_5/acre/d

UNIT PROCESS RELIABILITY - Generally resistant to upsets. Highly reliable if pH in the relatively narrow optimum range is maintained.

ENVIRONMENTAL IMPACT - May create odors. Have relatively high land requirements. There is potential for seepage of wastewater into groundwater unless lagoon is lined.

JOINT TREATMENT POTENTIAL - Valuable as a preliminary treatment process for combined industrial and municipal wastes containing high concentrations of organic materials. Can be used preceding most standard biological treatment processes.

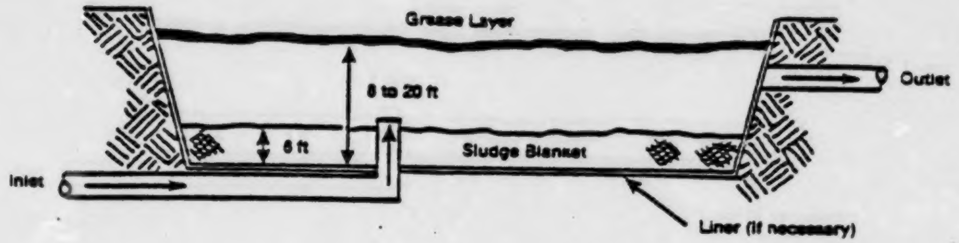
REFERENCES - 7, 16, 18, 20, 23, 67, 107, 110.

DRAFT SEP 1 1993

LAGOONS, ANAEROBIC

FACT SHEET 2.1.12

FLOW DIAGRAM -



ENERGY NOTES - Anaerobic lagoons are operated by gravity flow and therefore have no energy requirements other than any pumping that may be necessary to lift the influent wastewater into the lagoons.

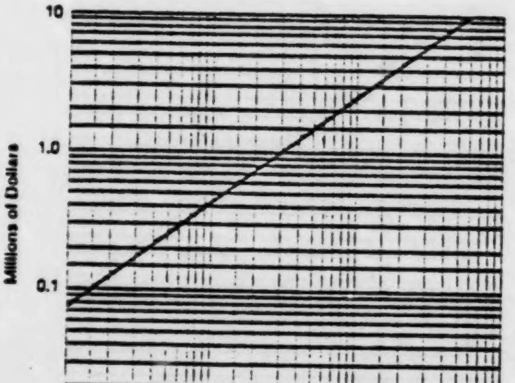
COSTS* - Assumptions: October 1982 dollars; ENR Index = 3875.
Service Life: 50 years
Average detention time = 35 days; depth = 10 ft; BOD_5 loading = 466 lb/acre/d. Construction cost includes excavating, grading and other earthwork and service roads. Costs do not include land and pumping. Liner costs not included in estimate. Operation and maintenance costs consist of labor and material.

Wastewater Characteristics	Influent, mg/l	Effluent, mg/l
BOD_5	600	240

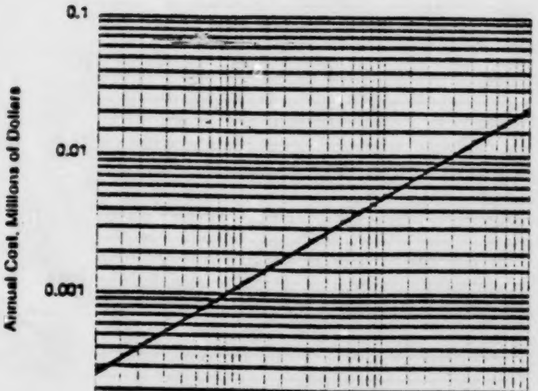
To adjust costs for other BOD_5 loadings and/or detention times, enter curve at effective flow (Q_E):

$$Q_E = Q_{DESIGN} \times \frac{(466\ \text{lb/acre/d})\ (\text{New detention time})}{(\text{New Design Loading})\ (35\ \text{days})}$$

Construction Cost



Operation & Maintenance Cost



REFERENCES - Curves derived from reference 3.

*To convert construction cost to capital cost see Table A-2.

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LAGOONS, FACULTATIVE

FACT SHEET 2.1.13

DESCRIPTION - Facultative lagoons are intermediate depth (3 to 8 feet) ponds in which the wastewater is stratified into three zones. These zones consist of an anaerobic bottom layer, an aerobic surface layer, and an intermediate zone. Stratification is a result of solids settling and temperature-water density variations. Oxygen in the surface stabilization zone is provided by reaeration and photosynthesis. This is in contrast to aerated lagoons in which mechanical aeration is used to create aerobic surface conditions. In general, the aerobic surface layer serves to reduce odors while providing treatment of soluble organic by-products of the anaerobic processes operting at the bottom.

Sludge at the bottom of facultative lagoons will undergo anaerobic digestion producing carbon dioxide, methane and cells. The photosynthetic activity at the lagoon surface produces oxygen diurnally, increasing the dissolved oxygen during daylight hours, while surface oxygen is depleted at night.

Facultative lagoons are often and for optimum performance should be operated in series. When three or more cells are linked, the effluent from either the second or third cell may be recirculated to the first. Recirculation rates of 0.5 to 2.0 times the plant flow have been used to improve overall performance.

COMMON MODIFICATIONS - Facultative lagoons are customarily contained within earthen dikes. Depending on soil characteristics, lining with various impervious materials such as rubber, plastic or clay may be necessary. Use of supplemental top layer aeration can improve overall treatment capacity, particularly in northern climates where icing over of facultative lagoons is common in the winter.

TECHNOLOGY STATUS - Fully demonstrated and in moderate use especially for treatment of relatively weak municipal wastewater in areas where real estate costs are not a restricting factor.

APPLICATIONS - Used for treating raw, screened, or primary settled domestic wastewaters and weak biodegradable industrial wastewaters. Most applicable when land costs are low and operation and maintenance costs are to be minimized.

LIMITATIONS - In very cold climates, facultative lagoons may experience reduced biological activity and treatment efficiency. Ice formation can also hamper operations. In overloading situations, odors can be a problem.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Lining systems/6; hydraulic controls/29.

PERFORMANCE - BOD_5 reductions of 75 to 95 percent have been reported. Effluent suspended solids concentrations of 20 to 150 mg/l can be expected, depending on the degree of algae separation achieved in the last cell. Efficiencies are strongly related to pond depth, detention time and temperature.

CHEMICALS REQUIRED - If wastewater is nutrient deficient, a source of supplemental nitrogen or phosphorus may be needed. No other chemicals are required.

RESIDUALS - Settled solids may require clean out and removal once every 10 to 20 years.

DESIGN CRITERIA -

Operation: At least three cells in series. Parallel trains of cells may be used for larger systems.
Detention time: 20 to 180 days.
Depth, ft: 3 to 8, although a portion of the anaerobic zone of the first cell may be up to 12 ft deep to accommodate large initial solids deposition.
pH: 6.5 to 9.0
Water temperature range: 35 to 90°F for municipal applications
Optimum water temperature: 68°F
Organic loading: 10 to 100 lb BOD_5/acre/d

PROCESS RELIABILITY - The service life of the lagoon is estimated to be 50 years. Little operator expertise is required. Overall, the system is highly reliable.

ENVIRONMENTAL IMPACT - There is potential for seepage of wastewater into groundwater unless lagoon is lined. Compared to other secondary processes, relatively small quantities of sludge are produced.

REFERENCES - 3, 7, 18, 23, 67, 109, 110.

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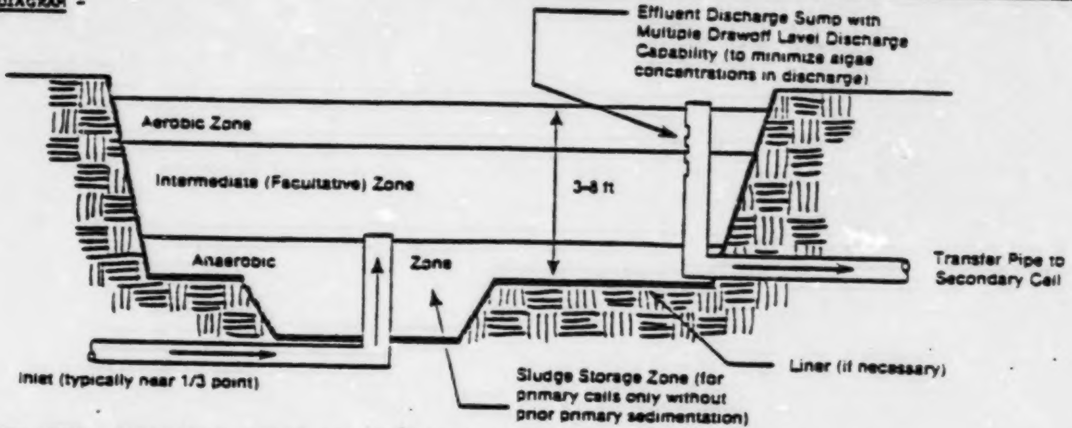
LAGOONS, FACULTATIVE

FACT SHEET 2.1.13

FLOW DIAGRAM -


Effluent Discharge Sump with Multiple Drawoff Level Discharge Capability (to minimize algae concentrations in discharge)
Aerobic Zone
Intermediate (Facultative) Zone
3-8 ft
Anaerobic
Zone
Transfer Pipe to Secondary Cell
Liner (if necessary)
Inlet (typically near 1/3 point)
Sludge Storage Zone (for primary cells only without prior primary sedimentation)

ENERGY NOTES - Facultative lagoons are operated by gravity and therefore have no energy requirements other than any pumping that may be necessary to lift the influent wastewater into the lagoons.

COSTS* - Assumptions:

1. Warm climate - lagoon loading = 40 lb BOD_5/acre/d.
2. Cool climate (northern U.S.) - lagoon loading = 20 lb BOD_5/acre/d.
3. Water depth = 4 ft.
4. Construction cost includes excavating, grading, and other earthwork required for normal subgrade preparation and service roads. Costs do not include land and pumping.
5. Process performance:

	Wastewater Characteristics	
	In	Out
BOD_5, mg/l	210	30
COD, mg/l	400	100
TSS, mg/l	230	60
Total-P, mg/l	11	8
NH_3-N, mg/l	20	15 (cool climate) 1 (warm climate)

6. No liner included in cost estimate.
7. ENR Index = 3875 (October 1982).

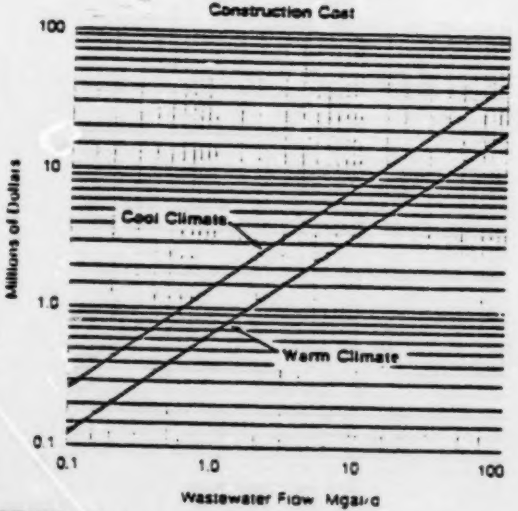
Adjustment Factor: To adjust costs for loadings other than those above, enter curve at effective flow (Q_E).

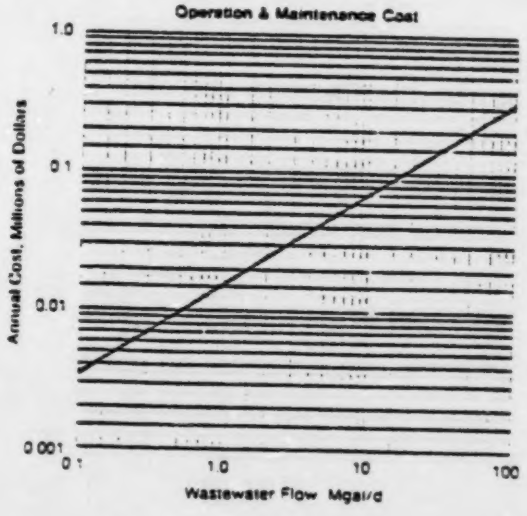
Warm Climates

$$Q_E = Q_{DESIGN} \times \frac{40\ \text{lb}\ BOD_5/\text{acre/day}}{\text{New Design Loading}}$$

Cool Climates

$$Q_E = Q_{DESIGN} \times \frac{20\ \text{lb}\ BOD_5/\text{acre/day}}{\text{New Design Loading}}$$





REFERENCES - 3.

*To convert construction cost to capital cost see Table A-2.

OXIDATION DITCH

FACT SHEET 2.1.15

DESCRIPTION - An oxidation ditch is an activated sludge biological treatment process commonly operated in the extended aeration mode, although conventional activated sludge treatment is also possible. Typical oxidation ditch treatment systems consist of a single or closed loop channel 4 to 6 ft deep, with 45° sloping sidewalls.

Some form of preliminary treatment such as screening, comminution or grit removal normally precedes the process. After pretreatment (primary clarification is usually not practiced) the wastewater is aerated in the ditch using mechanical aerators which are mounted across the channel. Horizontal brush, cage or disc-type aerators, specially designed for oxidation ditch applications, are normally used. The aerators provide mixing and circulation in the ditch, as well as sufficient oxygen transfer. Mixing in the channels is uniform, but zones of low dissolved oxygen concentration can develop. Aerators operate in the 60 to 110 RPM range and provide sufficient velocity to maintain solids in suspension. A high degree of nitrification may occur in the process without special modification because of the long detention times and high solid retention times (10 to 50 d) utilized. Secondary settling of the aeration ditch effluent is provided in a separate clarifier.

COMMON MODIFICATIONS - Ditches may be constructed of various materials, including concrete, gunite, asphalt, or impervious membranes. Concrete is the most common. Ditch loops may be oval or circular in shape. "Tll" and "horseshoe" configurations have been constructed to maximize land usage. Conventional activated sludge treatment, in contrast to extended aeration, may be practiced. Oxidation ditch systems with depths of 10 ft or more with vertical sidewalls and vertical shaft aerators may also be used.

TECHNOLOGY STATUS - There are nearly 650 shallow oxidation ditch installations in the United States and Canada. Numerous shallow and deep oxidation ditch systems are in operation in Europe. The overall process is fully demonstrated for carbon removal, as a secondary treatment process.

TYPICAL EQUIPMENT/NO. OF MFRS. (16, 23) - Oxidation ditch equipment (brush aerators, etc.)/6; hydraulic controls/29.

APPLICATIONS - Oxidation ditch technology is applicable in any situation where activated sludge treatment (conventional or extended aeration) is appropriate. The process cost of treatment is generally less than other biological processes in the range of wastewater flows between 0.1 and 10 Mgal/d.

LIMITATIONS - Oxidation ditches offer an added measure of reliability and performance over other biological processes but are subject to some of the same limitations that other activated sludge treatment processes face.

PERFORMANCE - The average performance of 29 shallow oxidation ditch plants is summarized below:

	Effluent, mg/l			Removal, Percent		
	Winter	Summer	Annual Avg.	Winter	Summer	Annual Avg.
BOD	15.2	1.2	12.3	92	94	93
Suspended Solids	13.6	9.3	10.5	93	94	94

40 to 80 percent ammonia nitrogen removal has been achieved.

CHEMICALS REQUIRED - None.

RESIDUALS GENERATED - No primary sludge is generated. Sludge produced is less volatile due to higher oxidation efficiency and increased solids retention times.

DESIGN CRITERIA - (Extended Aeration Mode).

BOD_5 Loading: 8.6 to 15 lb BOD_5/1000 ft^3 of aeration volume/d; sludge age: 10 to 33 d;
Channel Depth: 4 to 6 ft
Channel Geometry: 45 degree or vertical sidewalls
Aeration Channel Detention Time: 1 d

UNIT PROCESS RELIABILITY - The average reliability of 12 shallow oxidation ditch plants is summarized below:

	Percent of Time Effluent Concentration mg/l Less Than					
	10 mg/l		20 mg/l		30 mg/l	
	TSS	BOD	TSS	BOD	TSS	BOD
Average of all plants	65	65	85	90	94	96

ENVIRONMENTAL IMPACT - Solid waste, odor and air pollution impacts are similar to those encountered with standard activated sludge processes.

TOXICS MANAGEMENT - The same potential for sludge contamination, upsets and pass through of toxic pollutants exists for oxidation ditch plants as standard activated sludge processes.

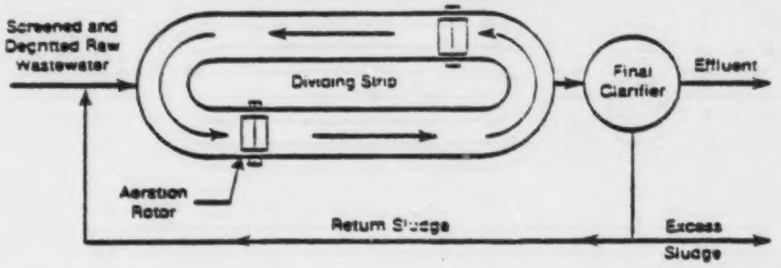
REFERENCES - 7, 16, 20, 23, 110, 259.

DRAFT SEP 1 1983

OXIDATION DITCH

FACT SHEET 2.1.15

FLOW DIAGRAM -


Screened and Degritted Raw Wastewater
Dividing Strip
Final Clarifier
Effluent
Aeration Rotor
Return Sludge
Excess Sludge

ENERGY NOTES - Energy requirements are for the total plant facilities which include electric drives for aerators, pump and other miscellaneous plant requirements. Influent BOD_5 assumed to be 200 mg/l.

Design Assumptions -

Oxygen transfer efficiency = 1.8 lb O_2/hph (wire to water). No appreciable nitrification occurs.

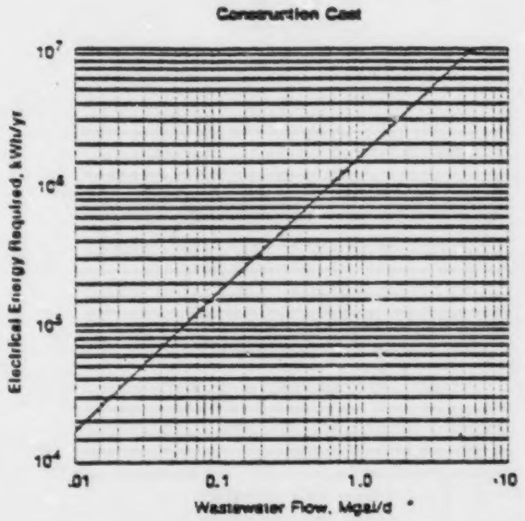
Operating Parameters -

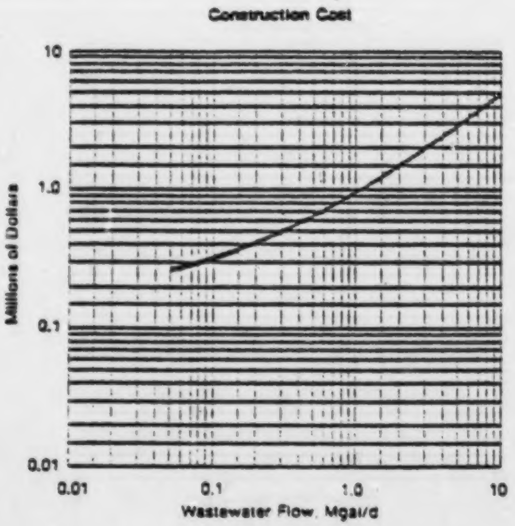
Oxygen requirement = 1.5 lb O_2/lb BOD_5 removed

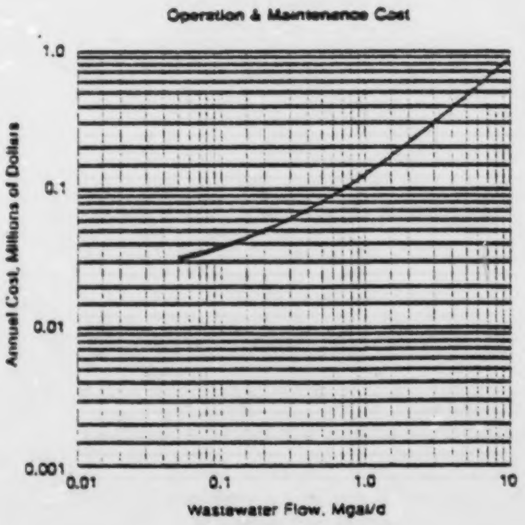
Type of Energy Required: Electrical

COSTS* - ENR Index = 3875 (October 1982).

Assumptions: Construction cost includes oxidation ditch, headworks, clarifier, pumps, building, laboratory, out-door sludge drying beds, but excludes land, engineering, legal and financing during construction. O&M costs include labor, utilities, chemicals, maintenance materials.







REFERENCES - 4, 16.

*To convert construction cost to capital cost see Table A-2.

DRAFT SEP 1 1983

BIOLOGICAL CONTACTORS, ROTATING (RBC) FACT SHEET 2.2.1

DESCRIPTION - The process is a fixed film biological reactor consisting of plastic media mounted on a horizontal shaft and placed in a tank. Common media forms are disc type made of styrofoam and a denser lattice type made of polyethylene. While wastewater flows through the tank, the media are slowly rotated, about 40% immersed, for contact with the wastewater for removal of organic matter by the biological film that develops on the media. Rotation results in exposure of the film to the atmosphere as a means of aeration. Excess biomass on the media is stripped off by rotational shear forces and the stripped solids are maintained in suspension by the mixing action of the rotating media. Multiple staging of RBC's increases treatment efficiency and could aid in achieving nitrification year round. A complete system could consist of two or more parallel trains with each train consisting of multiple stages in series.

COMMON MODIFICATIONS - Multiple staging; use of dense media for latter stages in train; use of molded covers or housing of units; various methods of pretreatment and after treatment of wastewater; use in combination with trickling filter or activated sludge processes; use of air driven system in lieu of mechanically driven system; addition of air to the tanks; addition of chemicals for pH control; and sludge recycle to enhance nitrification.

TECHNOLOGY STATUS - The process has only been in use in the United States since 1969 and thus is not yet in widespread use in this country. However, because of its characteristic modular construction, low hydraulic head loss and shallow excavation, which make it adaptable to new or existing treatment facilities, its use is growing.

APPLICATION - Treatment of domestic and compatible industrial wastewater amenable to aerobic biological treatment in conjunction with suitable pre and post treatment. Can be used for nitrification, roughing, secondary treatment and polishing.

LIMITATIONS - Can be vulnerable to climate changes and low temperatures if not housed or covered. Performance may diminish significantly at temperatures below 55°F. Enclosed units can result in considerable wintertime condensation if heat is not added to the enclosure. High organic loadings can result in first stage septicity and supplemental aeration may be required. Use of dense media for early stages can result in media clogging. Alkalinity deficit can result from nitrification; supplemental alkalinity source may be required.

TYPICAL EQUIPMENT/NO. MFRS. (10) - Rotating disc systems/5.

PERFORMANCE - Four stage system with final clarifier and preceded by primary treatment (percent removal).

BOD_5, 80-90%	SS, 80-90%	Phosphorus, 10-30%	NH_4-N, Up to 95%*

*Depending upon temperature, alkalinity, organic loading, and unoxidized nitrogen loading.

RESIDUALS GENERATED - Sludge in the secondary clarifier. 3000 to 4000 gal sludge/Mgal wastewater, 500 to 700 lb dry solids/Mgal wastewater.

DESIGN CRITERIA -

Organic Loading - Without nitrification - 30 to 60 lb BOD_5/d/1000 ft^3 media, with nitrification - 15 to 20 lb BOD_5/d/1000 ft^3 media
Hydraulic Loading - Without nitrification - 0.75 to 1.5 gal/d/ft^2 of media surface area, with nitrification - 0.3 to 0.6 gal/d/ft^2 of media surface area
Number of stages per train - 1-4 depending upon treatment objectives
Number of parallel trains - Recommended at least two
Rotational Velocity - Peripheral velocity = 60 ft/min for mechanically driven, 30-60 ft/min for air driven
Typical media surface area - Disc type - 20-25 ft^2/ft^3, standard lattice type - 30-40 ft^2/ft^3; high density lattice - 50-60 ft^2/ft^3
Percent media submerged - 40%
Tank volume = 0.12 gal/ft^2 of disc area
Detention time based on 0.12 gal/ft^2 - Without nitrification - 40-120 minutes, with nitrification - 90-250 minutes
Secondary clarifier overflow rate - 500-800 gal/d/ft^2
HP - 3.0-5.0 consumed/25 ft shaft; 5-7.5 connected/25 ft shaft

PROCESS AND MECHANICAL RELIABILITY - Moderately reliable in absence of high organic loading and temperatures below 55°F. Mechanical reliability is generally high provided first stage of system is designed to hold large biomass. Dense media in first stage can result in clogging and structural failure.

TOXICS MANAGEMENT - Little data exists concerning removal of toxics by this process. As with any fixed film process, this process is presumably sensitive to variable inputs of toxics. Treatability studies are advisable to determine degree of toxics removal.

ENVIRONMENTAL IMPACT - Negative impacts have not been documented. Presumably, odor can be a problem if septic conditions develop in the first stage.

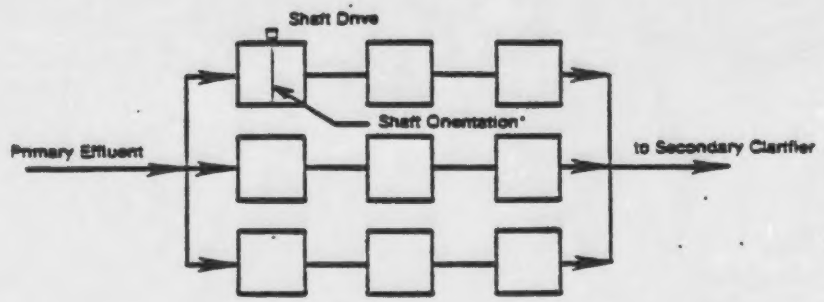
REFERENCES - 3, 4, 22, 28, 54, 60, 61, 62, 63, 233.

DRAFT SEP 1 1983

BIOLOGICAL CONTACTORS, ROTATING (RBC) FACT SHEET 2.2.1

FLOW DIAGRAM -

Typical Staged RBC Configuration



*Alternate shaft orientation is parallel to direction of flow with a common drive for all the stages in a single train.

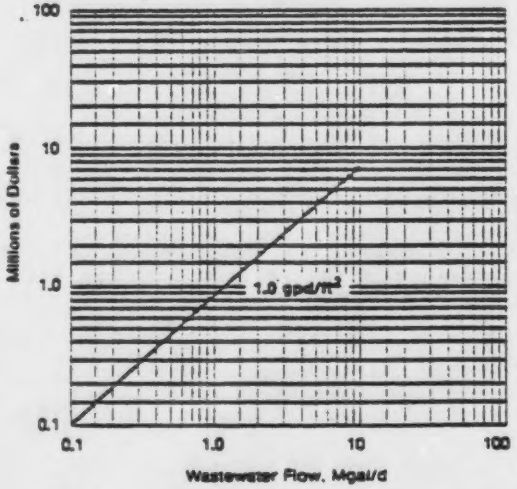
ENERGY NOTES - Approximate drive energy for operating the contactors can be determined from the following relationship:

kWh/yr = K x (Effective surface area of the biological contactor)
where K is 0.3 for standard media and 0.2 for dense media.

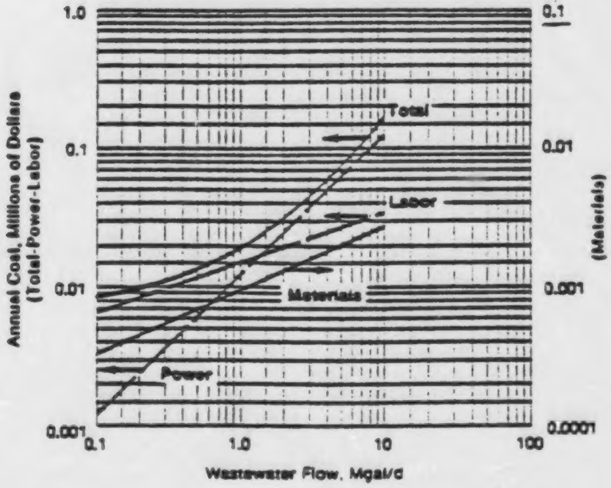
COSTS** - Assumptions: ENR Index = 3875 (October 1982).

1. Construction cost includes RBC shafts (standard media, 100,000 ft^2/shaft), motor drives (5 hp/shaft), molded fiberglass covers, and reinforced concrete basins.
2. Cost does not include primary and secondary clarifiers.
3. Loading rate - 1.0 gal/d/ft^2.
4. Treatment is for carbonaceous oxidation.

Construction Cost*



Operation & Maintenance Cost



REFERENCES - 3, 4.

**To convert construction cost to capital cost see Table A-2.

TRICKLING FILTER, PLASTIC MEDIA

FACT SHEET 2.2.6

DESCRIPTION - The process consists of a fixed bed of plastic media over which wastewater is applied for aerobic biological treatment. Zoogleal slimes form on the media which assimilate and oxidize substances in the wastewater. The bed is dosed by a distributor system, and the treated wastewater is collected by an underdrain system. Primary treatment is normally required to optimize trickling filter performance, whereas post-treatment is generally not required to meet secondary treatment.

The rotary distributor has become the standard because of its reliability and ease of maintenance, however, fixed nozzles are often used in roughing filters. Plastic media is comparatively light with a specific weight 10 to 30 times less than rock media. Its high void space (approximately 95 percent) promotes better oxygen transfer during passage through the filter than rock media with its approximate 50 percent void space. Because of its light weight, plastic media containment structures are normally constructed as elevated towers 20 to 30 feet high. Excavated containment structures for rock media can sometimes serve as a foundation for elevated towers for converting an existing facility to plastic media.

Plastic media trickling filters can be employed to provide independent secondary treatment or roughing ahead of a second-stage biological process. When used for secondary treatment, the media bed is generally circular in plan and dosed by a rotary distributor. Roughing applications often utilize rectangular media beds with fixed nozzles for distribution.

The organic material present in the wastewater is degraded by a population of microorganisms attached to the filter media. As the microorganisms grow, the thickness of the slime layer increases. Periodically, the liquid will wash some slime off the media, and a new slime layer will start to grow. This phenomenon of losing the slime layer is called sloughing and is primarily a function of the organic and hydraulic loadings on the filter. Filter effluent recirculation is vital with plastic media trickling filters to ensure proper wetting of the media and to promote effective sloughing control compatible with the high organic loadings employed.

COMMON MODIFICATIONS - Recirculation flow schemes, rate of recirculation, multistaging, electrically powered distributors, forced ventilation, filter covers, and use of various methods of pretreatment and post treatment of wastewater. Can also be used as a roughing filter at flow rates above 1400 gal/d/ft^2. Can be used as a separate stage nitrification process. Discussion of this application is presented in Fact Sheet 2.1.14.

TECHNOLOGY STATUS - Has been used as a modification of rock media filters for 10 to 20 years.

APPLICATIONS - Treatment of domestic and compatible industrial wastewaters amenable to aerobic biological treatment. Industrial and joint wastewater treatment facilities may use the process as a roughing filter prior to activated sludge or other unit processes. Existing rock filter facilities can be upgraded via elevation of the containment structure and conversion to plastic media. Can be used for nitrification following prior (first-stage) biological treatment.

LIMITATIONS - Vulnerable to below freezing weather, recirculation may be restricted during cold weather due to cooling effects, marginal treatment capability in single stage operation. It is less effective in treatment of wastewater containing high concentrations of soluble organics. Has limited flexibility and control in comparison with competing processes, and has potential for vector and odor problems although they are not as prevalent as with low rate rock media trickling filters. Long recovery times with upsets.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Underdrains/3; distributors/10; filter covers/2; plastic media/5.

PERFORMANCE - Employing the loadings listed below for secondary treatment and using a single-stage configuration with filter effluent recirculation and primary and secondary clarification (percent removal).
BOD_5 - 80 to 90 percent; Phosphorus - 10 to 30 percent; NH_4-N - 20 to 30 percent; SS - 80 to 90 percent

CHEMICALS REQUIRED - None.

RESIDUALS GENERATED - Sludge is withdrawn from the secondary clarifier at a rate of 3000 to 4000 gal/Mgal of wastewater, containing 500 to 700 lb dry solids.

DESIGN CRITERIA -

Hydraulic loading (with recirculation)
a. Secondary treatment - 15 to 90 Mgal/acre/d
350 to 2050 gal/d/ft^2
b. Roughing - 60 to 200 Mgal/acre/d
1400 to 4600 gal/d/ft^2
Recirculation ratio - 0.5:1 to 5:1
Dosing interval - Not more than 15 sec (continuous)
Sloughing - continuous

Organic loading
a. Secondary treatment - 450 to 1750 lb BOD_5/d/acre ft
10 to 40 lb BOD_5/d/1000 ft^3
b. Roughing - 4500 to 22,000 lb BOD_5/d/acre ft
100 to 500 lb BOD_5/d/1000 ft^3
Bed depth - 20 to 30 ft
Power requirements - 10 to 50 hp/Mgal
Underdrain minimum slope = 1%

PROCESS AND MECHANICAL RELIABILITY - The process can be expected to have a high degree of reliability if operating conditions minimize variability and the installation is in a climate where wastewater temperatures do not fall below 13°C for prolonged periods. Mechanical reliability is high. The process is simple to operate.

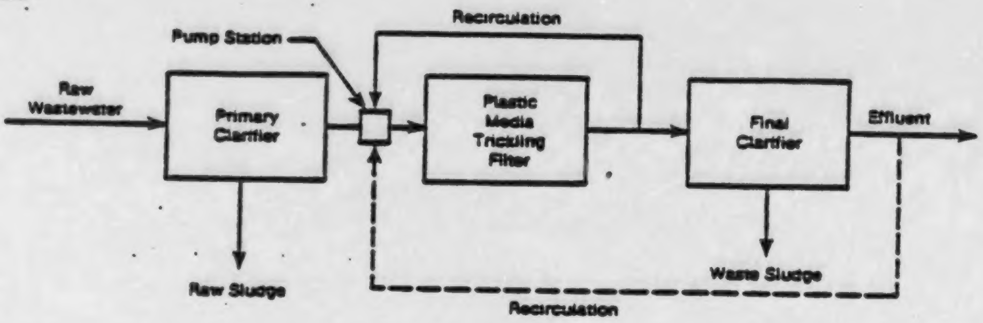
ENVIRONMENTAL IMPACT - Air: Odor problems if improperly operated.

REFERENCES - 7, 10, 22, 26, 27, 28, 29, 30, 31, 259.

TRICKLING FILTER, PLASTIC MEDIA

FACT SHEET 2.2.6

FLOW DIAGRAM -

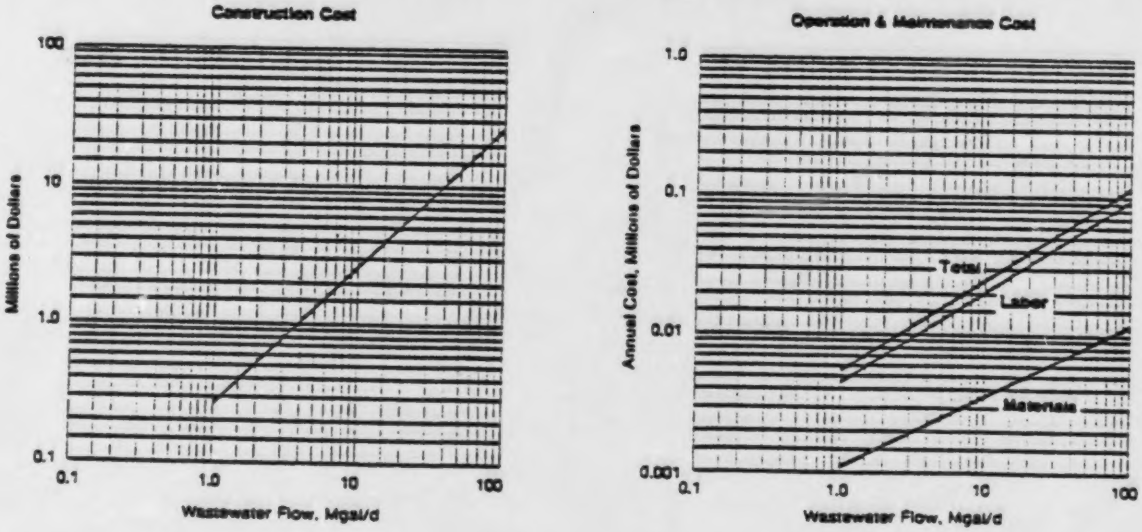


ENERGY NOTES - Pumping energy requirements may be approximated by using the following equation: kWh/yr = 1900 x Mgal/d x discharge head ft, assuming a wire-to-water efficiency of 60 percent. For the typical head requirement of 23 ft for this process, and assuming an average recirculation ratio of 2:1, an energy requirement of 131,000 kWh/yr/Mgal/d can be expected. Mgal = Influent Flow + Recirculation Flow.

Water Quality	Filter Influent (mg/l)	Effluent (mg/l)
BOD_5	130	ok
Suspended Solids	100	20

COSTS* - Assumptions: October 1982 dollars. ENR Index = 3875.

1. Construction costs shown are for carbonaceous oxidation and are based on: bed depth = 21 ft; hydraulic loading approximately 0.65 gal/min/ft^2 at an average recirculation ratio of 2:1; at organic loading = 20 lb BOD_5/1000 ft^3; concrete enclosures are precast concrete; foundations and supports are poured-in-place.
2. Construction cost includes plastic media, underdrains, distributors, and tower containment structures. Clarifiers and recirculation equipment not included.
3. Construction costs for single stage nitrification range 23-25% higher than those for carbonaceous oxidation.
4. O&M costs shown are for carbonaceous oxidation and do not include energy requirements associated with recirculation. There is no energy requirement for the plastic media trickling filter itself.
5. Labor including fringes = $14.80/h.
6. O&M costs for nitrification are approximately 12-15% higher than those for carbonaceous oxidation.



REFERENCES - 259.

*To convert construction cost to capital cost see Table A-2.

DRAFT SEP 1 1983

TRICKLING FILTER, HIGH RATE, ROCK MEDIA

FACT SHEET 2.2.7

DESCRIPTION - The process consists of a fixed bed of rock media over which wastewater is applied for aerobic biological treatment. Zoogleal slimes form on the media which assimilate and oxidize substances in the wastewater. The bed is dosed by a distributor system, and the treated wastewater is collected by an underdrain system. Primary treatment is normally required to optimize trickling filter performance, and post-treatment is often necessary to meet secondary standards or water quality limitations.

The rotary distributor has become the standard because of its reliability and ease of maintenance. It consists of two or more arms that are mounted on a pivot in the center of the filter. Nozzles distribute the wastewater as the arms rotate due to the dynamic action of the incoming primary effluent. Continuous recirculation of filter effluent is used to maintain a constant hydraulic loading to the distributor arms.

Underdrains are manufactured from specially designed vitrified-clay blocks that support the filter media and pass the treated wastewater to a collection sump for transfer to the final clarifier.

The filter media consists of 1- to 5-inch stone. The high rate trickling filter media bed generally is circular in plan, with a depth of 3 to 6 feet. Containment structures are normally made of reinforced concrete and installed in the ground to support the weight of the media.

The organic material present in the wastewater is degraded by a population of microorganisms attached to the filter media. As the microorganisms grow, the thickness of the slime layer increases. As the slime layer increases in thickness, the absorbed organic matter is metabolized before it can reach the microorganisms near the media face. As a result, the microorganisms near the media face enter into an endogenous phase of growth. In this phase, the microorganisms lose their ability to cling to the media surface. The liquid then washes the slime off the media, and a new slime layer will start to grow. This phenomenon of losing the slime layer is called sloughing and is primarily a function of the organic and hydraulic loadings on the filter. Filter effluent recirculation is vital with high rate trickling filters to promote the flushing action necessary for effective sloughing control, without which media clogging and anaerobic conditions could develop due to the high organic loading rates employed.

COMMON MODIFICATIONS - Various recirculation methods, rate of recirculation, multistaging, electrically powered distributors, forced ventilation, and filter covers.

TECHNOLOGY STATUS - In widespread use since 1936. A modification of the low rate trickling filter process.

APPLICATIONS - Treatment of domestic and compatible industrial wastewaters amenable to aerobic biological treatment in conjunction with suitable pre- and post-treatment. Industrial and joint wastewater treatment facilities may use the process as a roughing filter prior to activated sludge or other unit processes. The process is effective for removal of suspended or colloidal materials and is less effective for removal of soluble organics.

LIMITATIONS - Vulnerable to below freezing weather, recirculation may be restricted during cold weather due to cooling effects, marginal treatment capability in single stage operation. It is less effective in treatment of wastewater containing high concentrations of soluble organics. Has limited flexibility and control in comparison with competing processes, and has potential for vector and odor problems although they are not as prevalent as with low-rate trickling filters. Long recovery times with upsets. Limited to 60-80% BOD_5 removal.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Underdrains/3; distributors/10; filter covers/2.

PERFORMANCE - Single-stage configuration with filter effluent recirculation and primary and secondary clarification (percent removal).

BOD_5 - 60 to 80 percent; phosphorus - 10 to 30 percent; NH_4-N - 20 to 30 percent; SS - 60 to 80 percent

CHEMICALS REQUIRED - None.

RESIDUALS GENERATED - Sludge is withdrawn from the secondary clarifier at a rate of 2500 to 3000 gal/Mgal wastewater containing 400 to 500 lb dry solids.

DESIGN CRITERIA -

Hydraulic loading (with recirculation) - 10 to 50 Mgal/acre/d
230 to 1150 gal/d/ft^2
Recirculation ratio - 0.5:1 to 4:1
Dosing interval - Not more than 15 sec (continuous)
Sloughing - continuous
Rock, 1" to 5", (using square mesh screen. Must meet sodium sulfate soundness test)

Organic loading - 900 to 2600 lb BOD_5/d/acre ft
20 to 60 lb BOD_5/d/1000 ft^3
Bed depth - 3 to 6 ft
Power requirements - 10 to 50 hp/Mgal
Underdrain minimum slope - 1 percent Media -

PROCESS AND MECHANICAL RELIABILITY - The process can be expected to have a high degree of reliability if operating conditions minimize variability and the installation is in a climate where wastewater temperatures do not fall below 13°C for prolonged periods. Mechanical reliability is high. The process is simple to operate.

ENVIRONMENTAL IMPACT - Air: Odor problems if improperly operated.

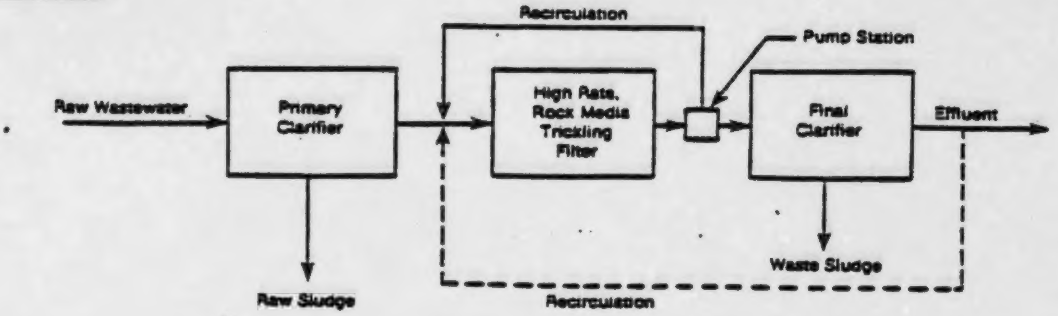
REFERENCES - 7, 10, 22, 26, 27, 28, 29, 30, 31.

DRAFT SEP 1 1983

TRICKLING FILTER, HIGH RATE, ROCK MEDIA

FACT SHEET 2.2.7

FLOW DIAGRAM -

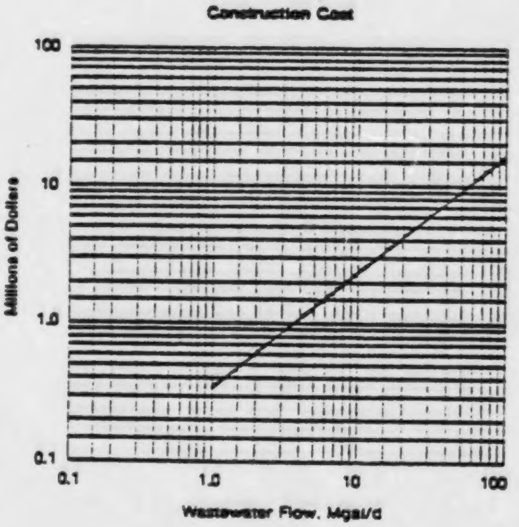

Recirculation
Pump Station
Raw Wastewater
Primary Clarifier
High Rate, Rock Media Trickling Filter
Final Clarifier
Effluent
Raw Sludge
Waste Sludge
Recirculation

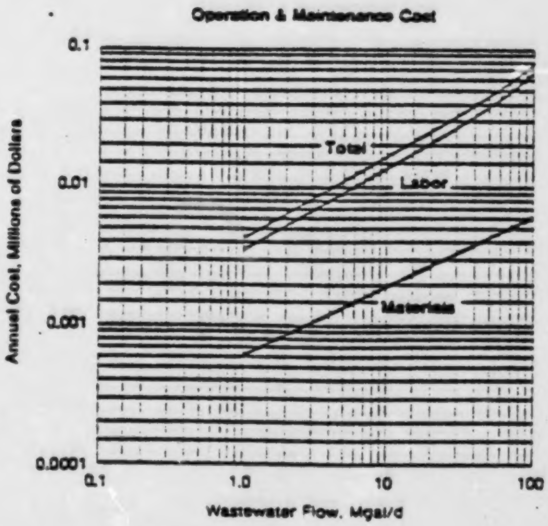
ENERGY NOTES - Pumping energy requirements may be approximated by using the following equation: kWh/yr = 1900 x Mgal/d x discharge head ft, assuming a wire-to-water efficiency of 60 percent. For the typical head requirement of 10 ft for this process and assuming an average recirculation ratio of 4:1, an energy requirement of 95,000 kWh/yr/Mgal/d can be expected. Mgal = Influent Flow + Recirculation Flow.

Water Quality	Filter Influent (mg/l)	Effluent (mg/l)
BOD_5	130	45
Suspended Solids	100	40

COSTS* - Assumptions: October 1982 dollars, ENR Index = 3875.

1. Construction cost based on: bed depth = 5 ft; organic loading = 20 lb BOD_5/d/1000 ft^3; recirculation ratio = 4.0 (at average daily flow) to 0.4 (at peak daily flow, assumed to equal 3.5 times average daily flow) to maintain average hydraulic loading = .75 gal/min/ft^2.
2. Cost includes rock media, underdrains, distributors, and reinforced concrete containment structures. Clarifier and recirculation equipment not included.
3. Operation and maintenance cost includes labor at $11.80/h and materials. Does not include energy costs.





REFERENCES - 287, 259.

*To convert construction cost to capital cost see Table A-1.

DRAFT SEP 1 1983

TRICKLING FILTER, LOW RATE, ROCK MEDIA

FACT SHEET 2.2.8

DESCRIPTION - The process consists of a fixed bed of rock media over which wastewater is applied for aerobic biological treatment. Zoogleal slimes form on the media which assimilate and oxidize substances in the wastewater. The bed is dosed by a distributor system, and the treated wastewater is collected by an underdrain system. Recirculation is usually not used. Primary treatment is normally required to optimize trickling filter performance.

The rotary distributor has become the standard because of its reliability and ease of maintenance. In contrast to the high rate trickling filter which uses continuous recirculation of filter effluent to maintain a constant hydraulic loading to the distributor arms, either a suction-level controlled pump or a dosing siphon is employed for that purpose with a low rate filter. Nevertheless, programmed rest periods may be necessary at times because of inadequate influent flow.

Underdrains are manufactured from specially designed vitrified-clay blocks that support the filter media and pass the treated wastewater to a collection sump for transfer to the final clarifier. The filter media consists of 1- to 5-inch stone. Containment structures are normally made of reinforced concrete and installed in the ground to support the weight of the media.

The low rate trickling filter media bed generally is circular in plan, with a depth of 5 to 10 feet. Although filter effluent recirculation is generally not utilized, it can be provided as a standby tool to keep filter media wet during low flow periods.

The organic material present in the wastewater is degraded by a population of microorganisms attached to the filter media. As the microorganisms grow, the thickness of the slime layer increases. Periodically, wastewater washes the slime off the media, and a new slime layer will start to grow. This phenomenon of losing the slime layer is called sloughing and is primarily a function of the organic and hydraulic loadings on the filter.

COMMON MODIFICATIONS - Addition of recirculation, multistaging, electrically powered distributors, forced ventilation, filter covers, and use of various methods of pretreatment and post-treatment of wastewater.

TECHNOLOGY STATUS - In widespread use, this process is highly dependable in moderate climates. Use of after-treatment or multistaging has frequently been found necessary to ensure uniform compliance with effluent limitations in colder regions. Being superseded by changes to plastic media systems.

APPLICATIONS - Treatment of domestic and compatible industrial wastewaters amenable to aerobic biological treatment in conjunction with suitable pretreatment. This process is good for removal of suspended or colloidal materials and is somewhat less effective for removal of soluble organics. Can be used for nitrification following prior (first-stage) biological treatment or as a stand-alone process in warm climates if the organic loading is low enough.

LIMITATIONS - Vulnerable to climate changes and low temperatures, filter flies and odors are common, periods of inadequate moisture for slimes can be common, less effective in treatment of wastewater containing high concentrations of soluble organics, limited flexibility and process control in comparison with competing processes, high land and capital cost requirements, and recovery times of several weeks with upsets.

TYPICAL EQUIPMENT/NO. OF MFRS. (23) - Underdrains/3; distributors/10; filter covers/2.

PERFORMANCE - Single-stage configuration with primary and secondary clarification and no recirculation (percent removal). BOD_5 - 75 to 90%; Phosphorus - 10 to 30%; NH_4-N - 20 to 40%; SS - 75 to 90%

RESIDUALS GENERATED - Sludge is withdrawn from the secondary clarifier at a rate of 3,000 to 4,000 gal/Mgal of wastewater, containing 500 to 700 lb dry solids.

DESIGN CRITERIA -

Hydraulic Loading - 1 to 4 Mgal/acre/d; 25 to 90 gal/d/ft^2
Organic Loading - 200 to 900 lb BOD_5/d/acre ft;
5 to 20 lb BOD_5/d/1000 ft^3
Dosing interval - Continuous for majority of daily operating schedule, but may become intermittent (not more than 5 min) during low flow periods
Effluent channel minimum velocity = 2 ft/s at average daily flow
Media - rock, 1 in. to 5 in., must meet sodium sulfate soundness test

Recirculation ratio - 0
Depth - 5 to 10 ft
Sloughing - Intermittent
Underdrain minimum slope = 1%

PROCESS AND MECHANICAL RELIABILITY - Highly reliable under conditions of moderate climate. Mechanical reliability high. Process operation requires little skill.

ENVIRONMENTAL IMPACT - Odor problems; high land requirement relative to many alternative processes; and filter flies.

REFERENCES - 7, 10, 22, 26, 27, 28, 29, 30, 31.

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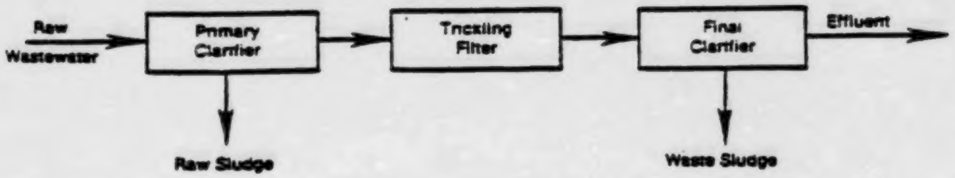
TRICKLING FILTER, LOW RATE, ROCK MEDIA

FACT SHEET 2.2.8

FLOW DIAGRAM -



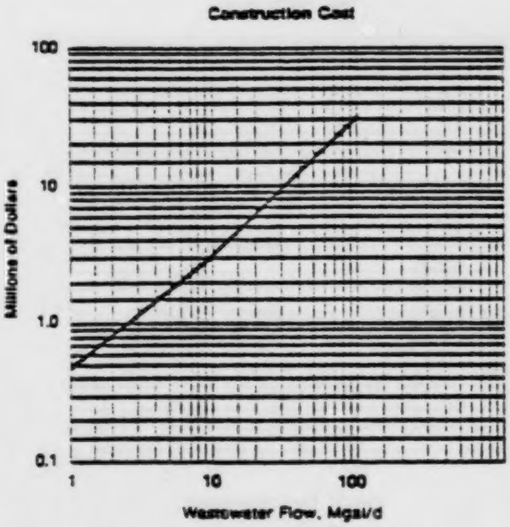
ENERGY NOTES - Assumptions: The process requires a hydraulic head for operation. Pumping energy requirements may be approximated by using the following equation: kWh/yr = 1900 (Mgal/d) x (discharge head, ft), assuming a wire-to-water efficiency of 60 percent. For the typical head requirement of 10 ft for this process, an energy requirement of 19,000 kWh/yr/Mgal/d can be expected. Mgal = Influent flow + Recirculation flow (although recirculation flow is normally zero or intermittent).

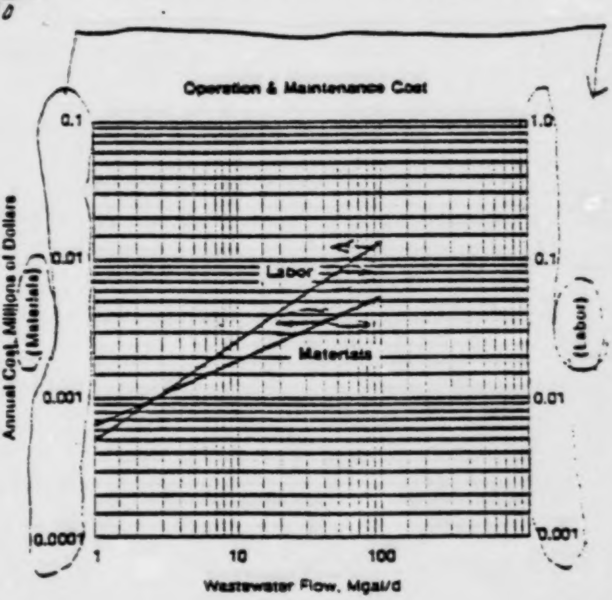
Water Quality	Filter Influent (mg/l)	Effluent (mg/l)
BOD_5	130	25
Suspended Solids	100	25

COSTS* - Assumptions: (October 1982 prices) ENR Index = 3875.

1. Construction cost based on: bed depth = 8 ft; organic loading = 10 lb BOD_5/d/1000 ft^3; hydraulic loading = 75 gal/d/ft^2; recirculation ratio = 0.
2. Construction cost includes reinforced concrete containment structures, rotating distributors, rock media, and underdrains. Clarifiers and recirculation equipment not included.
3. Operation and maintenance cost includes labor at $11.80/h and materials. Does not include energy costs, if any.

$12.10





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REFERENCES - 207.

*To convert construction cost to capital cost see Table A-2.

APPENDIX D

SUMMARY OF COMPLIANCE FREQUENCY BY TREATMENT PROCESS TYPE

TABLE D-1

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - ROCK - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	95.31	96.88	96.88	100.00	100.00	100.00
85	93.75	93.75	96.88	98.44	100.00	100.00
80	92.19	93.75	96.88	98.44	100.00	100.00
75	92.19	92.19	96.88	98.44	100.00	100.00
70	87.50	90.63	95.31	98.44	100.00	100.00
65	85.94	85.94	93.75	95.31	98.44	100.00
60	76.56	79.69	89.06	93.75	98.44	100.00
55	73.44	75.00	84.38	92.19	96.88	100.00
50	62.50	65.63	75.00	82.81	93.75	96.88
45	59.38	59.38	65.63	78.13	90.63	95.31
40	46.88	48.44	57.81	68.75	84.38	93.75
35	32.81	37.50	50.00	56.25	70.31	90.63
30	17.19	21.88	35.94	45.31	60.94	78.13
25	6.25	9.38	14.06	23.44	37.50	62.50
20	0.00	0.00	3.13	9.38	25.00	40.63
15	0.00	0.00	1.56	1.56	6.25	18.75
10	0.00	0.00	1.56	1.56	1.56	6.25

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - ROCK - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	92.19	92.19	96.88	100.00	100.00	100.00
85	92.19	92.19	96.88	100.00	100.00	100.00
80	90.63	90.63	96.88	98.44	100.00	100.00
75	89.06	89.06	95.31	98.44	100.00	100.00
70	84.38	87.50	95.31	96.88	100.00	100.00
65	81.25	84.38	93.75	96.88	100.00	100.00
60	81.25	84.38	92.19	96.88	100.00	100.00
55	76.56	79.69	87.50	96.88	100.00	100.00
50	70.31	73.44	81.25	93.75	100.00	100.00
45	56.25	57.81	71.88	87.50	98.44	100.00
40	48.44	50.00	59.38	75.00	96.88	100.00
35	39.06	42.19	51.56	64.06	87.50	98.44
30	28.13	29.69	42.19	51.56	70.31	93.75
25	18.75	20.31	28.13	34.38	51.56	75.00
20	6.25	9.38	14.06	21.88	31.25	50.00
15	4.69	4.69	6.25	7.81	15.63	31.25
10	3.13	3.13	3.13	4.69	7.81	14.06

TABLE D-2

PERCENTAGE OF FACILITIES MEETING
A GIVEN BOD EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.
WINTER DATA.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	100.00	100.00	100.00	100.00	100.00	100.00
70	94.12	94.12	94.12	100.00	100.00	100.00
65	94.12	94.12	94.12	94.12	100.00	100.00
60	88.24	88.24	88.24	94.12	94.12	100.00
55	88.24	88.24	88.24	88.24	94.12	94.12
50	82.35	82.35	82.35	88.24	94.12	94.12
45	70.59	70.59	70.59	82.35	82.35	94.12
40	70.59	70.59	70.59	70.59	82.35	94.12
35	58.82	58.82	58.82	58.82	76.47	88.24
30	41.18	41.18	47.06	52.94	76.47	82.35
25	35.29	35.29	41.18	47.06	52.94	64.71
20	17.65	17.65	23.53	29.41	35.29	47.06
15	5.88	5.88	5.88	5.88	17.65	23.53
10	0.00	0.00	0.00	5.88	5.88	17.65

PERCENTAGE OF FACILITIES MEETING
A GIVEN TSS EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.
WINTER DATA

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	100.00	100.00	100.00	100.00	100.00	100.00
70	100.00	100.00	100.00	100.00	100.00	100.00
65	100.00	100.00	100.00	100.00	100.00	100.00
60	100.00	100.00	100.00	100.00	100.00	100.00
55	100.00	100.00	100.00	100.00	100.00	100.00
50	94.12	94.12	94.12	100.00	100.00	100.00
45	88.24	88.24	94.12	94.12	100.00	100.00
40	88.24	88.24	88.24	88.24	94.12	94.12
35	76.47	76.47	88.24	88.24	88.24	94.12
30	64.71	64.71	82.35	88.24	88.24	88.24
25	41.18	41.18	47.06	64.71	76.47	88.24
20	23.53	23.53	23.53	29.41	58.82	70.59
15	17.65	17.65	17.65	17.65	29.41	58.82
10	5.88	5.88	5.88	11.76	11.76	29.41

TABLE D-3

PERCENTAGE OF FACILITIES MEETING
A GIVEN BOD EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.
SUMMER DATA

	% OF TIME					
EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	100.00	100.00	100.00	100.00	100.00	100.00
70	94.12	94.12	100.00	100.00	100.00	100.00
65	94.12	94.12	94.12	94.12	100.00	100.00
60	94.12	94.12	94.12	94.12	100.00	100.00
55	94.12	94.12	94.12	94.12	94.12	100.00
50	88.24	88.24	88.24	88.24	94.12	94.12
45	82.35	82.35	82.35	88.24	94.12	94.12
40	82.35	82.35	82.35	82.35	88.24	94.12
35	70.59	70.59	70.59	76.47	82.35	88.24
30	64.71	64.71	64.71	64.71	70.59	82.35
25	47.06	47.06	47.06	52.94	64.71	70.59
20	35.29	35.29	35.29	41.18	41.18	64.71
15	23.53	23.53	23.53	23.53	35.29	52.94
10	11.76	11.76	17.65	17.65	17.65	29.41

PERCENTAGE OF FACILITIES MEETING
A GIVEN TSS EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.
SUMMER DATA

	% OF TIME					
EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	100.00	100.00	100.00	100.00	100.00	100.00
70	100.00	100.00	100.00	100.00	100.00	100.00
65	100.00	100.00	100.00	100.00	100.00	100.00
60	100.00	100.00	100.00	100.00	100.00	100.00
55	100.00	100.00	100.00	100.00	100.00	100.00
50	100.00	100.00	100.00	100.00	100.00	100.00
45	82.35	82.35	82.35	88.24	94.12	100.00
40	82.35	82.35	82.35	82.35	94.12	94.12
35	82.35	82.35	82.35	82.35	82.35	94.12
30	76.47	76.47	76.47	76.47	82.35	82.35
25	64.71	64.71	76.47	76.47	76.47	82.35
20	47.06	47.06	52.94	58.82	58.82	64.71
15	17.65	17.65	23.53	47.06	47.06	52.94
10	5.88	5.88	5.88	5.88	29.41	35.29

TABLE D-4

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	94.12	94.12	100.00	100.00	100.00	100.00
70	94.12	94.12	94.12	100.00	100.00	100.00
65	94.12	94.12	94.12	94.12	100.00	100.00
60	88.24	88.24	94.12	94.12	94.12	100.00
55	88.24	88.24	94.12	94.12	94.12	100.00
50	76.47	76.47	88.24	94.12	94.12	100.00
45	64.71	64.71	70.59	88.24	94.12	94.12
40	58.82	64.71	70.59	76.47	94.12	94.12
35	47.06	47.06	58.82	64.71	82.35	94.12
30	35.29	41.18	47.06	58.82	64.71	82.35
25	23.53	29.41	35.29	47.06	52.94	70.59
20	0.00	0.00	23.53	35.29	47.06	52.94
15	0.00	0.00	5.88	11.76	23.53	47.06
10	0.00	0.00	0.00	0.00	11.76	29.41

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME TRICKLING FILTER - PLASTIC - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	100.00	100.00	100.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	100.00	100.00	100.00	100.00	100.00	100.00
70	100.00	100.00	100.00	100.00	100.00	100.00
65	100.00	100.00	100.00	100.00	100.00	100.00
60	100.00	100.00	100.00	100.00	100.00	100.00
55	94.12	100.00	100.00	100.00	100.00	100.00
50	88.24	94.12	100.00	100.00	100.00	100.00
45	70.59	82.35	94.12	94.12	94.12	100.00
40	70.59	70.59	82.35	94.12	94.12	94.12
35	58.82	70.59	70.59	76.47	94.12	94.12
30	47.06	52.94	64.71	76.47	94.12	94.12
25	35.29	35.29	52.94	64.71	70.59	88.24
20	5.88	11.76	23.53	41.18	58.82	76.47
15	5.88	5.88	11.76	17.65	41.18	47.06
10	0.00	0.00	5.88	5.88	17.65	29.41

TABLE D-5

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
A.S. - CONVENTIONAL - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	93.94	96.97	100.00	100.00	100.00	100.00
85	93.94	95.45	100.00	100.00	100.00	100.00
80	92.42	93.94	100.00	100.00	100.00	100.00
75	90.91	92.42	98.48	100.00	100.00	100.00
70	89.39	89.39	98.48	100.00	100.00	100.00
65	89.39	89.39	93.94	100.00	100.00	100.00
60	86.36	86.36	92.42	98.48	100.00	100.00
55	81.82	84.85	90.91	95.45	100.00	100.00
50	78.79	80.30	87.88	93.94	100.00	100.00
45	75.76	78.79	84.85	92.42	98.48	100.00
40	69.70	74.24	81.82	87.88	96.97	100.00
35	65.15	68.18	78.79	83.33	92.42	98.48
30	60.61	62.12	72.73	80.30	87.88	96.97
25	43.94	45.45	59.09	68.18	84.85	93.94
20	33.33	36.36	46.97	56.06	68.18	87.88
15	7.58	12.12	31.82	39.39	54.55	71.21
10	1.52	1.52	4.55	19.70	30.30	45.45

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
A.S. - CONVENTIONAL - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	87.88	89.39	93.94	96.97	100.00	100.00
85	84.85	87.88	93.94	96.97	100.00	100.00
80	83.33	87.88	90.91	96.97	100.00	100.00
75	78.79	81.82	90.91	96.97	100.00	100.00
70	77.27	78.79	89.39	96.97	100.00	100.00
65	74.24	75.76	89.39	93.94	98.48	100.00
60	74.24	74.24	84.85	92.42	98.48	100.00
55	66.67	69.70	81.82	89.39	96.97	100.00
50	63.64	65.15	80.30	89.39	95.45	100.00
45	60.61	62.12	74.24	84.85	93.94	100.00
40	54.55	59.09	69.70	80.30	87.88	98.48
35	46.97	53.03	63.64	72.73	87.88	95.45
30	39.39	43.94	59.09	65.15	81.82	92.42
25	30.30	33.33	51.52	60.61	72.73	86.36
20	21.21	24.24	39.39	51.52	62.12	80.30
15	4.55	6.06	21.21	37.88	54.55	68.18
10	1.52	1.52	3.03	7.58	31.82	51.52

TABLE D-6

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACT. SLUDGE - CONVENTIONAL - 30-DAY MOVING AVGS.
PRE PL 92-500 FACILITIES

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	93.75	95.83	100.00	100.00	100.00	100.00
85	93.75	95.83	100.00	100.00	100.00	100.00
80	91.67	93.75	100.00	100.00	100.00	100.00
75	89.58	91.67	97.92	100.00	100.00	100.00
70	89.58	89.58	97.92	100.00	100.00	100.00
65	89.58	89.58	93.75	100.00	100.00	100.00
60	87.50	87.50	91.67	97.92	100.00	100.00
55	83.33	85.42	91.67	95.83	100.00	100.00
50	79.17	81.25	87.50	93.75	100.00	100.00
45	79.17	81.25	83.33	93.75	97.92	100.00
40	70.83	77.08	81.25	87.50	97.92	100.00
35	66.67	70.83	79.17	83.33	91.67	100.00
30	62.50	62.50	72.92	81.25	89.58	97.92
25	43.75	43.75	58.33	66.67	85.42	97.92
20	29.17	33.33	45.83	54.17	64.58	95.83
15	8.33	10.42	29.17	35.42	52.08	89.58
10	0.00	0.00	4.17	18.75	29.17	70.83

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACT. SLUDGE - CONVENTIONAL - 30-DAY MOVING AVGS.
PRE PL 92-500 FACILITIES

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	87.50	87.50	91.67	95.83	100.00	100.00
85	85.42	87.50	91.67	95.83	100.00	100.00
80	83.33	87.50	89.58	95.83	100.00	100.00
75	79.17	81.25	89.58	95.83	100.00	100.00
70	77.08	79.17	89.58	95.83	100.00	100.00
65	75.00	77.08	89.58	93.75	97.92	100.00
60	75.00	75.00	85.42	93.75	97.92	100.00
55	66.67	70.83	83.33	93.75	95.83	100.00
50	62.50	64.58	81.25	93.75	93.75	100.00
45	58.33	60.42	75.00	87.50	93.75	100.00
40	52.08	56.25	68.75	83.33	91.67	97.92
35	41.67	50.00	60.42	72.92	91.67	95.83
30	37.50	43.75	56.25	62.50	85.42	91.67
25	29.17	33.33	50.00	60.42	72.92	89.58
20	22.92	25.00	35.42	47.92	62.50	83.33
15	2.08	4.17	16.67	35.42	52.08	68.75
10	0.00	0.00	2.08	6.25	29.17	50.00

TABLE D-7

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACT. SLUDGE - CONVENTIONAL - 30-DAY MOVING AVGS.
POST PL 92-500 FACILITIES
% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	94.44	100.00	100.00	100.00	100.00	100.00
85	94.44	94.44	100.00	100.00	100.00	100.00
80	94.44	94.44	100.00	100.00	100.00	100.00
75	94.44	94.44	100.00	100.00	100.00	100.00
70	88.89	88.89	100.00	100.00	100.00	100.00
65	88.89	88.89	94.44	100.00	100.00	100.00
60	83.33	83.33	94.44	100.00	100.00	100.00
55	77.78	83.33	88.89	94.44	100.00	100.00
50	77.78	77.78	88.89	94.44	100.00	100.00
45	66.67	72.22	88.89	88.89	100.00	100.00
40	66.67	66.67	83.33	88.89	94.44	100.00
35	61.11	61.11	77.78	83.33	94.44	100.00
30	55.56	61.11	72.22	77.78	83.33	94.44
25	44.44	50.00	61.11	72.22	83.33	88.89
20	44.44	44.44	50.00	61.11	77.78	83.33
15	5.56	16.67	38.89	50.00	61.11	72.22
10	5.56	5.56	5.56	22.22	33.33	50.00

Enclosed areas indicate where the percentage of plants meeting the concentration with the given reliability is greater for Post PL 92-500 plants than Pre PL 92-500 plants.

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACT. SLUDGE - CONVENTIONAL - 30-DAY MOVING AVGS.
POST PL 92-500 FACILITIES
% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	88.89	94.44	100.00	100.00	100.00	100.00
85	83.33	88.89	100.00	100.00	100.00	100.00
80	83.33	88.89	94.44	100.00	100.00	100.00
75	77.78	83.33	94.44	100.00	100.00	100.00
70	77.78	77.78	88.89	100.00	100.00	100.00
65	72.22	72.22	88.89	94.44	100.00	100.00
60	72.22	72.22	83.33	88.89	100.00	100.00
55	66.67	66.67	77.78	77.78	100.00	100.00
50	66.67	66.67	77.78	77.78	100.00	100.00
45	66.67	66.67	72.22	77.78	94.44	100.00
40	61.11	66.67	72.22	72.22	77.78	100.00
35	61.11	61.11	72.22	72.22	77.78	94.44
30	44.44	44.44	66.67	72.22	72.22	94.44
25	33.33	33.33	55.56	61.11	72.22	77.78
20	16.67	22.22	50.00	61.11	61.11	72.22
15	11.11	11.11	33.33	44.44	61.11	66.67
10	5.56	5.56	5.56	11.11	38.89	55.56

TABLE D-8

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
ACTIVATED SLUDGE - CONT. STAB. - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	94.74	94.74	96.49	98.25	100.00	100.00
85	94.74	94.74	96.49	98.25	100.00	100.00
80	91.23	92.98	96.49	98.25	100.00	100.00
75	85.96	89.47	96.49	98.25	100.00	100.00
70	85.96	87.72	94.74	98.25	100.00	100.00
65	84.21	85.96	91.23	98.25	100.00	100.00
60	78.95	78.95	87.72	96.49	100.00	100.00
55	75.44	77.19	82.46	94.74	98.25	100.00
50	73.68	73.68	82.46	91.23	98.25	100.00
45	71.93	73.68	77.19	87.72	98.25	100.00
40	66.67	68.42	75.44	85.96	96.49	100.00
35	57.89	63.16	71.93	77.19	92.98	100.00
30	47.37	54.39	66.67	73.68	82.46	98.25
25	40.35	43.86	54.39	66.67	77.19	91.23
20	28.07	31.58	43.86	54.39	70.18	80.70
15	17.54	17.54	22.81	31.58	54.39	70.18
10	3.51	3.51	8.77	17.54	29.82	52.63

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
ACTIVATED SLUDGE - CONT. STAB. - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	85.97	85.97	96.49	98.25	100.00	100.00
85	84.21	84.21	94.74	98.25	100.00	100.00
80	84.21	84.21	92.98	98.25	100.00	100.00
75	84.21	84.21	71.23	96.49	100.00	100.00
70	82.46	82.46	89.47	96.49	100.00	100.00
65	78.95	82.46	87.72	96.49	100.00	100.00
60	77.19	77.19	84.21	92.98	98.25	100.00
55	73.68	75.44	78.95	89.47	96.49	100.00
50	71.93	71.93	78.95	87.72	96.49	100.00
45	70.18	71.93	77.19	87.72	94.74	100.00
40	63.16	64.91	71.93	80.70	94.74	98.25
35	57.89	61.40	70.18	77.19	92.98	98.25
30	40.35	43.86	66.67	70.18	89.47	98.25
25	35.09	36.84	50.88	64.91	77.19	94.74
20	22.81	26.32	40.35	52.63	63.16	87.72
15	12.28	15.79	26.32	36.84	50.88	64.91
10	1.75	3.51	12.28	17.54	36.84	50.88

TABLE D-9

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACTIVATED SLUDGE - EXT. AERATION - 30-DAY MOVING AVGS.

	% OF TIME					
EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	96.43	96.43	100.00	100.00	100.00	100.00
85	96.43	96.43	100.00	100.00	100.00	100.00
80	96.43	96.43	100.00	100.00	100.00	100.00
75	96.43	96.43	100.00	100.00	100.00	100.00
70	96.43	96.43	100.00	100.00	100.00	100.00
65	96.43	96.43	100.00	100.00	100.00	100.00
60	96.43	96.43	100.00	100.00	100.00	100.00
55	96.43	96.43	100.00	100.00	100.00	100.00
50	96.43	96.43	100.00	100.00	100.00	100.00
45	92.86	92.86	96.43	100.00	100.00	100.00
40	85.71	89.29	96.43	100.00	100.00	100.00
35	78.57	78.57	96.43	100.00	100.00	100.00
30	75.00	75.00	82.14	96.43	100.00	100.00
25	71.43	75.00	78.57	89.29	92.86	100.00
20	60.71	67.86	75.00	82.14	89.29	96.43
15	50.00	50.00	60.71	71.43	82.14	92.86
10	32.14	39.29	50.00	57.14	67.86	89.29

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME

ACTIVATED SLUDGE - EXT. AERATION - 30-DAY MOVING AVGS.

	% OF TIME					
EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	96.43	96.43	96.43	100.00	100.00	100.00
85	96.43	96.43	96.43	100.00	100.00	100.00
80	96.43	96.43	96.43	100.00	100.00	100.00
75	96.43	96.43	96.43	100.00	100.00	100.00
70	96.43	96.43	96.43	100.00	100.00	100.00
65	96.43	96.43	96.43	96.43	100.00	100.00
60	92.86	92.86	96.43	96.43	100.00	100.00
55	92.86	92.86	96.43	96.43	100.00	100.00
50	89.29	89.29	89.29	96.43	100.00	100.00
45	85.71	85.71	89.29	96.43	100.00	100.00
40	82.14	82.14	89.29	92.86	100.00	100.00
35	82.14	82.14	82.14	89.29	96.43	100.00
30	71.43	71.43	78.57	82.14	92.86	100.00
25	57.14	57.14	67.86	75.00	85.71	96.43
20	46.43	46.43	64.29	67.86	75.00	85.71
15	42.86	42.86	50.00	50.00	64.29	82.14
10	25.00	25.00	32.14	39.29	57.14	57.14

TABLE D-10

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
R.B.C. - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	88.89	92.59	100.00	100.00	100.00	100.00
85	88.89	92.59	100.00	100.00	100.00	100.00
80	88.89	92.59	100.00	100.00	100.00	100.00
75	88.89	92.59	100.00	100.00	100.00	100.00
70	85.19	92.59	96.30	100.00	100.00	100.00
65	85.19	88.89	96.30	100.00	100.00	100.00
60	81.48	85.19	96.30	96.30	100.00	100.00
55	81.48	85.19	96.30	96.30	100.00	100.00
50	77.78	81.48	92.59	96.30	100.00	100.00
45	70.37	74.07	92.59	92.59	100.00	100.00
40	66.67	74.07	88.89	92.59	100.00	100.00
35	59.26	59.26	77.78	85.19	100.00	100.00
30	44.44	44.44	59.26	74.07	88.89	100.00
25	25.93	25.93	44.44	51.85	70.37	96.30
20	18.52	18.52	25.93	33.33	55.56	74.07
15	7.41	11.11	11.11	18.52	33.33	66.67
10	0.00	0.00	0.00	7.41	14.81	18.52

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME
R.B.C. - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	100.00	100.00	00.00	100.00	100.00	100.00
85	100.00	100.00	.00.00	100.00	100.00	100.00
80	100.00	100.00	100.00	100.00	100.00	100.00
75	96.30	100.00	100.00	100.00	100.00	100.00
70	96.30	96.30	100.00	100.00	100.00	100.00
65	92.59	96.30	100.00	100.00	100.00	100.00
60	92.59	92.59	100.00	100.00	100.00	100.00
55	85.19	85.19	100.00	100.00	100.00	100.00
50	81.48	85.19	96.30	100.00	100.00	100.00
45	70.37	74.07	92.59	100.00	100.00	100.00
40	66.67	70.37	81.48	96.30	100.00	100.00
35	62.96	66.67	77.78	92.59	100.00	100.00
30	59.26	59.26	70.37	85.19	100.00	100.00
25	37.04	40.74	62.96	74.07	100.00	100.00
20	18.52	22.22	40.74	55.56	74.07	100.00
15	7.41	11.11	22.22	33.33	51.85	66.67
10	0.00	0.00	3.70	14.81	33.33	44.44

TABLE D-11

PERCENTAGE OF FACILITIES MEETING A GIVEN BOD EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME OXIDATION DITCH - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	100.00	100.00	100.00	100.00	100.00	100.00
85	96.43	96.43	100.00	100.00	100.00	100.00
80	96.43	96.43	100.00	100.00	100.00	100.00
75	96.43	96.43	100.00	100.00	100.00	100.00
70	96.43	96.43	100.00	100.00	100.00	100.00
65	96.43	96.43	100.00	100.00	100.00	100.00
60	96.43	96.43	100.00	100.00	100.00	100.00
55	96.43	96.43	96.43	100.00	100.00	100.00
50	89.29	89.29	96.43	100.00	100.00	100.00
45	85.71	89.29	96.43	100.00	100.00	100.00
40	82.14	82.14	85.71	96.43	100.00	100.00
35	82.14	82.14	85.71	92.86	100.00	100.00
30	82.14	82.14	82.14	89.29	92.86	100.00
25	64.29	64.29	78.57	82.14	89.29	100.00
20	50.00	53.57	67.86	78.57	85.71	92.86
15	42.36	42.86	50.00	71.43	82.14	85.71
10	25.00	25.00	28.57	35.71	75.00	82.14

PERCENTAGE OF FACILITIES MEETING A GIVEN TSS EFFLUENT CONCENTRATION FOR A GIVEN PERCENT OF TIME OXIDATION DITCH - 30-DAY MOVING AVGS.

EFF. CONC. (MG/L)	% OF TIME 100%	99%	95%	90%	75%	50%
90	82.14	82.14	92.86	96.43	100.00	100.00
85	82.14	82.14	92.86	96.43	100.00	100.00
80	82.14	82.14	92.86	96.43	100.00	100.00
75	82.14	82.34	89.29	96.43	100.00	100.00
70	82.14	82.14	89.29	96.43	100.00	100.00
65	75.00	78.57	89.29	96.43	100.00	100.00
60	67.86	71.43	89.29	89.29	100.00	100.00
55	67.86	67.86	85.71	89.29	100.00	100.00
50	60.71	60.71	85.71	89.29	100.00	100.00
45	60.71	60.71	75.00	85.71	100.00	100.00
40	60.71	60.71	67.86	82.14	100.00	100.00
35	50.00	53.57	64.29	75.00	92.86	100.00
30	46.43	46.43	60.71	67.86	92.86	100.00
25	46.43	46.43	53.57	64.29	78.57	96.43
20	35.71	39.29	46.43	50.00	75.00	92.86
15	25.00	25.00	35.71	42.86	57.14	89.29
10	10.71	10.71	21.43	28.57	39.29	60.71

TABLE D-12

PERCENTAGE OF FACILITIES MEETING
A GIVEN BOD EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
STABILIZATION POND - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	91.89	91.89	97.30	97.30	97.30	100.00
85	91.89	91.89	94.59	97.30	97.30	100.00
80	91.89	91.89	94.59	97.30	97.30	100.00
75	86.49	86.49	91.89	97.30	97.30	100.00
70	83.78	83.78	89.19	97.30	97.30	100.00
65	83.78	83.78	86.49	91.89	97.30	100.00
60	78.38	78.38	83.78	91.89	97.30	100.00
55	72.97	72.97	81.08	86.49	97.30	97.30
50	67.57	67.57	78.38	81.08	91.89	97.30
45	62.16	62.16	72.97	81.08	91.89	97.30
40	54.05	54.05	62.16	78.38	83.78	94.59
35	40.54	43.24	56.76	62.16	75.68	89.19
30	24.32	24.32	45.95	54.05	70.27	81.08
25	10.81	10.81	24.32	29.73	48.65	75.68
20	5.41	5.41	5.41	16.22	35.14	56.76
15	0.00	0.00	0.00	5.41	8.11	29.73
10	0.00	0.00	0.00	0.00	5.41	8.11

PERCENTAGE OF FACILITIES MEETING
A GIVEN TSS EFFLUENT CONCENTRATION
FOR A GIVEN PERCENT OF TIME
STABILIZATION POND - 30-DAY MOVING AVGS.

% OF TIME

EFF. CONC. (MG/L)	100%	99%	95%	90%	75%	50%
90	56.76	56.76	62.16	72.98	89.19	97.30
85	56.76	56.76	62.16	70.27	83.78	94.59
80	51.35	51.35	59.46	67.57	81.08	94.59
75	43.24	43.24	56.76	64.86	81.08	94.59
70	37.84	40.54	56.76	59.46	75.68	94.59
65	29.73	29.73	54.05	56.76	70.27	89.19
60	27.03	27.03	48.65	56.76	64.86	81.08
55	18.92	18.92	29.73	43.24	59.46	78.38
50	18.92	18.92	18.92	40.54	56.76	72.97
45	13.51	13.51	18.92	21.62	48.65	72.97
40	10.81	10.81	13.51	13.51	40.54	64.86
35	5.41	5.41	8.11	10.81	21.62	51.35
30	5.41	5.41	5.41	5.41	10.81	45.95
25	5.41	5.41	5.41	5.41	8.11	29.73
20	2.70	2.70	2.70	5.41	5.41	10.81
15	0.00	0.00	0.00	2.70	5.41	8.11
10	0.00	0.00	0.00	0.00	2.70	2.70

APPENDIX E

TECHNICAL DATA SUMMARY TABLES

TABLE E-1

RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
1	ADD.PROCESS	115	7.13	216	6.93	8.71
55		505	8.49	591	8.46	10.93
523	ADD.PROCESS	110	9.43	191	9.45	12.70
17	ADD.PROCESS	190	8.96	312	9.10	13.00
525	ADD.PROCESS	112	8.72	205	8.56	15.25
130	ADD.PROCESS	105	12.10	122	12.19	15.92
21	ADD.PROCESS	120	13.14	187	13.42	16.09
308	ADD.PROCESS	390	11.55	366	11.67	16.39
302	ADD.PROCESS	760	10.17	732	10.08	17.40
215		93	13.48	176	13.48	19.00
22	ADD.PROCESS	52	16.58	95	16.49	20.33
905	OUTLIER	303	15.83	392	15.50	21.54
221	ADD.PROCESS	105	12.24	191	11.89	22.54
670	OUTLIER	71	16.87	124	17.20	23.67
60		23	18.96	42	19.32	23.85
260		95	20.63	178	20.57	24.16
303		751	18.43	732	18.51	24.28
25	ADD.PROCESS	10	15.50	14	16.32	24.33
666		205	14.66	325	14.54	24.34
201		103	15.86	179	15.84	24.60
650		134	14.62	279	15.11	25.43
601	ADD.PROCESS	90	20.77	137	20.58	25.43
552		21	12.48	38	12.42	25.57
554		24	14.42	45	14.27	27.10
138	ADD.PROCESS	492	19.08	579	19.03	27.65
555		50	18.26	94	18.43	27.67
971		274	22.43	377	21.98	28.37
309		696	22.00	728	21.76	28.55
2		148	19.27	237	19.34	29.04
963		337	16.39	490	15.96	29.45
406		323	14.00	431	13.79	29.79
304		446	23.33	561	23.24	30.12
665		225	22.32	336	22.40	30.29
603		112	23.15	154	22.64	30.84
306		131	25.82	132	25.39	31.09
253		101	18.54	176	18.60	31.29
53		493	29.11	580	29.10	31.73
52		503	21.26	583	20.93	32.05
527		97	19.52	179	19.59	32.18
214		92	25.27	162	25.07	32.46
522	ADD.PROCESS	715	19.71	731	19.82	32.63
657*		294	23.96	553	24.20	33.17
434	OUTLIER	308	19.68	403	19.32	33.53
202		204	27.67	380	27.33	34.56
655		268	29.08	366	29.22	34.73
970		164	26.23	295	26.28	35.67
524*		519	28.35	594	28.26	35.75

TABLE E-1 (Con't)

RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
BOD5 EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
325		235	25.08	297	24.33	36.33
345		326	29.94	606	29.93	36.67
604		260	29.12	289	28.83	38.18
50	ADD.PROCESS	729	22.37	703	22.33	38.57
602	ADD.PROCESS	104	29.81	149	29.54	39.14
216		104	27.68	190	27.82	40.20
550		24	20.71	44	20.40	40.50
956		105	23.53	179	22.48	40.60
121	ADD.PROCESS	353	20.60	453	19.98	40.97
244		26	25.19	45	25.27	41.10
119	ADD.PROCESS	240	27.98	342	27.78	42.18
255		49	19.98	91	20.88	43.00
653		282	40.08	381	40.00	43.14
953		96	37.05	171	36.79	44.16
412		221	34.64	323	34.58	44.76
954		293	29.33	434	28.48	45.00
952		207	33.75	394	33.54	45.14
191	OUTLIER	305	26.70	396	26.23	46.62
171		57	34.74	90	35.12	48.39
220		23	17.35	40	17.92	49.50
51		502	32.09	589	32.12	50.25
553		110	30.03	191	30.88	50.60
249		114	34.20	212	34.40	50.71
252		158	22.59	232	22.64	52.02
307		297	35.59	410	35.89	53.79
125	ADD.PROCESS	288	35.45	462	35.83	53.80
222		72	29.82	129	30.43	54.54
305		310	39.34	421	39.35	54.99
906		315	36.26	439	35.21	56.00
651		628	32.23	688	31.94	56.60
950		99	35.61	180	35.11	57.10
965		201	33.64	383	33.09	58.13
551		24	35.58	46	35.83	59.25
418		285	49.13	407	49.48	65.00
254		41	31.61	75	31.65	66.00
54		499	29.42	595	29.67	67.17
56		724	50.46	702	50.46	68.80
656		274	54.68	434	54.79	75.87
258	OUTLIER	47	51.74	88	51.41	90.12
149	OUTLIER	689	54.75	700	55.47	91.98
311		262	57.58	344	58.46	98.79
951		56	37.79	88	35.94	105.87
170	OUTLIER	89	85.78	163	85.65	110.32
411	OUTLIER	315	89.23	419	88.82	115.14
301	ADD.PROCESS	760	57.92	733	59.02	133.52
100	OUTLIER	244	86.38	469	86.50	134.69
409	OUTLIER	239	61.90	450	60.81	134.73

TABLE E-2

RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
953		0	.	0	.	.
970		0	.	0	.	.
952		0	.	0	.	.
523	ADD.PROCESS	109	8.91	191	9.02	11.25
17	ADD.PROCESS	195	8.37	318	8.25	11.57
25	ADD.PROCESS	10	8.60	14	8.38	12.67
260		94	9.36	175	9.51	13.01
308	ADD.PROCESS	395	11.16	366	11.27	13.90
301	ADD.PROCESS	759	11.33	733	11.34	14.73
22	ADD.PROCESS	52	11.15	95	11.24	14.75
657		512	9.25	600	9.23	15.43
905	OUTLIER	304	9.13	393	8.82	15.71
55		106	10.26	188	10.36	17.20
527		94	14.53	170	14.47	17.20
21	ADD.PROCESS	120	12.51	187	12.65	17.71
1	ADD.PROCESS	209	13.05	304	12.58	17.79
221	ADD.PROCESS	105	14.42	191	13.99	19.24
253		103	12.09	180	12.10	20.40
956		8	11.63	14	10.86	21.00
522	ADD.PROCESS	735	12.22	730	12.43	21.10
2		140	16.01	226	16.07	21.19
971		275	16.15	378	15.97	21.26
406		323	9.19	431	8.95	22.31
555		50	15.98	94	16.17	23.62
304		446	17.03	561	16.93	23.92
302	ADD.PROCESS	759	17.21	732	16.96	24.25
525	ADD.PROCESS	117	12.59	213	12.62	24.75
215		93	16.68	176	16.44	24.80
130	ADD.PROCESS	105	15.33	122	15.67	25.11
325		233	19.39	295	19.51	25.34
554		24	15.83	45	16.28	26.00
216		69	20.03	128	19.96	26.00
552		21	12.48	38	12.42	27.17
214		84	21.96	148	21.69	27.59
121	ADD.PROCESS	355	16.88	455	16.57	27.82
409	OUTLIER	239	20.18	450	20.00	27.96
50	ADD.PROCESS	732	22.16	703	22.22	28.09
305		310	23.44	421	23.41	28.46
309		694	21.91	730	21.66	29.30
666		253	15.56	417	15.80	29.64
201		103	22.61	179	22.43	30.00
60		8	25.25	15	25.60	30.00
670	OUTLIER	95	11.05	179	11.19	30.00
306		131	27.10	132	26.99	30.60
303		757	19.44	732	19.64	30.71
604		261	23.89	289	23.72	33.43
655		285	26.14	379	26.24	33.60

TABLE E-2 (Cont.)

RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
TSS EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
553		117	20.08	205	20.76	33.88
52		503	27.79	583	27.59	34.53
345		326	28.87	606	28.80	36.28
665		417	20.27	535	20.20	36.96
602	ADD.PROCESS	64	28.45	108	28.77	37.56
252		312	29.12	389	29.45	37.68
651		635	26.87	686	26.75	38.90
656		276	29.73	439	29.61	40.14
550		23	15.91	42	15.87	40.25
963		348	22.29	434	21.67	40.77
653		481	40.38	584	40.33	43.68
249		105	29.30	201	28.87	43.83
412		83	29.19	127	29.18	45.02
255		49	19.06	92	19.94	45.33
906		315	27.70	440	27.31	45.37
54		106	26.66	181	25.91	45.60
307		297	35.01	410	35.15	45.62
524		519	26.94	594	26.69	46.76
601	ADD.PROCESS	93	27.28	138	27.46	47.07
191	OUTLIER	304	24.12	395	23.60	47.55
56		727	29.31	702	28.88	47.72
551		24	27.17	46	27.43	47.77
244		27	21.60	47	22.24	48.00
418		303	30.22	420	30.57	48.07
202		187	33.26	346	33.59	49.78
222		37	36.62	64	37.43	51.25
311		262	34.66	344	35.02	52.93
650		182	26.63	281	26.54	55.53
125	ADD.PROCESS	288	43.59	462	43.37	55.63
254		43	27.21	79	27.96	57.00
220		23	27.70	40	27.66	57.22
119	ADD.PROCESS	253	36.75	353	37.85	59.02
51		52	31.06	96	31.82	59.87
954		13	28.23	22	28.18	60.20
171		75	32.95	118	32.55	62.49
170	OUTLIER	89	47.57	163	47.68	64.40
434	OUTLIER	313	41.46	407	41.63	66.54
603		114	26.84	158	28.62	66.91
138	ADD.PROCESS	507	32.83	590	32.95	69.18
965		24	21.46	47	21.60	72.00
950		18	37.06	32	37.38	89.67
100	OUTLIER	252	76.12	485	76.18	95.30
149	OUTLIER	690	66.26	700	65.97	96.58
411	OUTLIER	318	81.57	422	81.28	104.28
53		23	36.30	45	36.53	117.50
258	OUTLIER	48	79.17	91	79.37	131.40
951		3	101.33	5	73.60	240.00

TABLE E-3

RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
BOD5 EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
354		292	7.18	416	6.97	14.40
102	ADD. PROCESS	517	10.17	693	10.23	14.56
350		200	11.18	363	11.29	21.33
323		285	16.38	536	16.64	21.60
114	ADD. PROCESS	716	16.67	702	16.55	23.47
194		93	18.98	172	18.53	23.69
352		12	22.96	20	23.21	29.00
435		711	16.23	700	16.53	29.79
115	ADD. PROCESS	479	13.80	579	13.56	31.38
101	ADD. PROCESS	419	25.31	579	25.49	33.25
967	ADD. PROCESS	279	20.46	526	20.47	37.89
162	ADD. PROCESS	913	31.22	913	31.28	39.53
353		193	16.36	283	16.34	40.09
907	OUTLIER	302	31.58	404	31.56	40.57
103	ADD. PROCESS	295	33.89	358	34.42	48.88
120	OUTLIER	287	42.21	382	42.08	50.52
605		70	36.04	117	36.11	51.52
174		185	25.62	255	25.67	52.40
351		103	29.30	189	29.37	55.80
104	ADD. PROCESS	303	55.42	361	56.19	75.25
113	OUTLIER	218	74.74	314	77.45	150.34
223	OUTLIER	88	70.56	166	69.81	204.88

TABLE E- 4

RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
102	ADD. PROCESS	503	6.66	590	6.65	11.02
354		297	5.76	422	5.91	13.62
115	ADD. PROCESS	483	11.14	579	11.08	17.44
114	ADD. PROCESS	729	13.64	702	13.61	20.07
967	ADD. PROCESS	279	10.47	526	10.30	21.67
323		285	19.36	536	19.50	23.84
351		108	13.63	196	13.60	25.80
194		106	19.87	195	19.90	26.00
162	ADD. PROCESS	913	16.13	913	16.00	26.68
352		12	21.27	20	22.29	27.48
350		203	11.74	367	11.91	27.98
353		197	20.59	287	20.20	29.07
103	ADD. PROCESS	311	25.77	371	25.64	34.02
435		713	16.52	701	16.85	38.58
101	ADD. PROCESS	438	22.72	553	23.04	41.87
907	OUTLIER	304	32.01	399	31.98	46.31
605		204	27.47	267	28.91	46.44
174		256	22.49	328	22.52	47.59
104	ADD. PROCESS	329	42.83	383	43.29	51.78
120	OUTLIER	296	64.04	388	64.02	82.47
223	OUTLIER	45	48.90	84	47.01	90.35
113	OUTLIER	214	67.97	311	72.21	150.73

TABLE E- 5

RANK ORDER OF OXIDATION DITCH FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
512		91	2.94	159	2.91	5.32
514		91	3.33	160	3.28	5.71
652		96	4.14	160	4.22	6.18
505		105	6.27	190	6.30	9.18
988		101	4.51	191	4.50	9.36
990		48	8.02	84	7.99	9.86
912	ADD. PROCESS	204	6.04	374	6.01	10.07
911		124	5.92	205	6.12	11.00
982		79	7.04	140	6.85	11.70
986		68	9.62	128	9.44	13.40
985		93	6.77	173	6.75	13.44
571		24	7.75	45	7.88	14.00
983		50	9.54	88	9.50	14.00
513		104	7.54	188	7.44	15.17
234		55	8.60	96	8.85	15.63
663		100	10.15	121	9.17	16.77
242		48	8.28	88	8.23	18.72
987		66	8.08	125	8.18	19.80
572		46	8.83	77	9.39	20.17
23		36	9.06	65	8.92	21.80
575		23	8.52	43	8.65	24.60
909		269	17.81	516	17.85	25.92
984		69	9.89	121	9.69	26.13
506		105	8.00	189	8.15	29.22
993		82	15.98	148	16.50	32.99
573		9	22.00	16	23.63	44.00
980		54	26.00	88	27.12	46.19
574		20	29.25	33	30.21	46.95
34		42	15.60	75	16.29	63.93
231	OUTLIER	47	42.55	86	42.83	66.97
611	OUTLIER	13	194.00	19	196.05	200.00

TABLE E- 6

RANK ORDER OF OXIDATION DITCH FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
983		74	3.74	136	3.65	7.66
512		91	4.82	159	4.94	8.00
514		91	5.23	160	5.42	8.00
912	ADD. PROCESS	144	7.29	255	7.38	8.78
505		104	7.63	186	7.66	10.60
611	OUTLIER	9	10.67	13	10.49	10.80
990		47	8.74	84	8.72	10.92
506		104	7.30	187	7.36	11.20
571		24	7.29	45	7.34	12.00
988		99	7.23	188	7.10	12.22
652		626	8.45	702	8.49	13.38
513		105	9.12	190	9.15	13.40
982		85	10.57	153	10.54	17.03
911		127	10.02	209	10.27	20.33
234		71	11.28	126	11.65	21.00
663		108	13.24	136	13.07	21.03
573		8	14.88	13	16.35	26.00
986		86	11.08	156	10.85	26.11
572		46	16.20	77	16.61	28.65
984		71	15.58	125	15.45	29.16
909		286	19.76	547	19.85	35.92
980		61	13.28	100	12.47	38.81
34		44	13.84	79	14.19	40.75
993		85	17.16	155	17.95	44.00
23		36	17.53	65	15.24	44.12
231	OUTLIER	48	28.75	85	28.75	46.80
242		48	20.34	89	19.65	51.47
985		89	31.55	165	31.88	52.58
574		20	26.10	33	27.45	71.00
987		71	25.63	135	25.90	79.64
575		23	23.74	43	24.79	97.00

TABLE E-7

RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
153		27	8.59	40	8.14	18.00
123		40	13.18	59	11.97	20.00
176		20	12.95	30	12.78	22.27
342		294	15.38	393	15.44	22.81
165		54	16.35	78	14.85	22.88
192	OUTLIER	61	10.32	109	10.92	23.74
111		36	14.56	53	15.65	24.75
137		47	15.99	70	16.56	26.56
134		35	14.89	52	14.94	27.44
168		35	21.06	50	19.08	29.67
131		18	18.95	26	19.58	29.91
186		8	8.86	13	8.71	30.00
166		20	11.80	30	12.78	30.05
169		81	17.22	129	16.99	30.42
156		76	15.82	111	16.24	30.77
106		45	23.60	67	23.16	31.60
659		40	18.97	74	19.20	32.00
133		51	21.63	74	22.50	33.16
136		32	24.04	47	24.62	33.33
187		8	13.79	11	12.39	35.00
654		46	24.13	85	24.07	36.00
112		63	24.70	83	24.11	36.95
674	OUTLIER	46	29.76	86	29.95	38.50
63		8	30.50	14	31.50	40.00
62	OUTLIER	8	30.38	14	30.57	42.00
65	OUTLIER	8	24.38	14	23.29	44.00
660	OUTLIER	44	25.80	82	26.52	45.33
132		43	26.81	63	29.79	46.12
167		28	22.71	42	21.72	48.00
124		44	23.16	68	24.58	52.72
122		34	29.59	48	28.74	53.37
340	OUTLIER	7	40.57	12	42.46	56.00
59		23	24.61	43	25.05	58.60
344	OUTLIER	22	40.52	41	41.49	62.15
61	OUTLIER	4	45.75	6	46.50	63.00
339	OUTLIER	6	35.92	10	30.95	65.00
64	OUTLIER	7	39.43	12	37.67	71.00
402		50	21.08	90	21.92	72.42
664	OUTLIER	37	43.64	65	44.71	74.06
338	OUTLIER	24	42.33	45	42.92	75.20
341	OUTLIER	7	45.86	12	48.17	78.00
337	OUTLIER	104	41.12	197	42.05	92.60
157	OUTLIER	21	49.94	35	53.63	127.20
658	OUTLIER	48	70.96	89	72.67	136.25
343	OUTLIER	345	49.29	453	48.48	142.35

TABLE E-3

RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

FACILITY	OUTLIER FACILITY	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
192	OUTLIER	61	6.68	109	6.36	13.83
342		298	12.69	403	12.76	18.30
186		10	12.60	16	11.27	26.50
137		47	21.62	70	22.14	34.77
122		34	28.06	48	25.93	38.82
111		36	21.31	53	22.16	38.85
176		20	19.45	30	20.17	45.67
63		2	26.00	4	26.00	46.00
64	OUTLIER	2	42.50	3	44.00	47.00
168		35	25.66	50	24.81	49.66
123		40	26.66	59	25.35	57.25
165		53	29.28	77	29.12	58.20
124		44	27.39	68	27.03	59.14
131		18	40.42	26	38.92	60.80
153		27	23.78	40	23.52	60.95
156		71	31.32	107	31.92	61.46
402		52	27.32	93	27.24	61.50
136		31	39.51	46	45.00	62.26
61	OUTLIER	2	47.00	3	52.33	63.00
654		46	42.65	85	44.07	65.00
343	OUTLIER	343	45.93	451	45.98	65.31
134		35	33.00	52	35.03	68.00
112		64	42.32	85	44.52	69.16
344	OUTLIER	22	42.72	41	43.97	69.70
106		45	38.04	67	43.21	71.60
674	OUTLIER	46	43.83	86	45.37	72.16
337	OUTLIER	104	59.68	197	59.62	78.40
166		20	24.85	30	25.57	79.22
339	OUTLIER	6	57.48	10	57.12	85.60
167		28	63.68	42	62.92	97.85
338	OUTLIER	24	47.58	45	48.57	98.50
132		43	47.49	63	53.26	102.63
658	OUTLIER	48	65.61	89	64.93	105.33
340	OUTLIER	7	54.00	12	56.33	109.00
187		8	59.13	11	72.12	111.00
157	OUTLIER	25	47.20	38	49.55	114.32
169		81	40.79	129	42.28	115.46
133		51	53.75	74	58.72	122.27
341	OUTLIER	7	66.29	12	69.33	135.00
59		18	37.78	34	37.24	140.00
659		40	51.82	74	53.72	156.50
62	OUTLIER	2	100.50	4	100.50	157.00
660	OUTLIER	44	77.09	82	78.87	215.00
65	OUTLIER	2	133.00	4	133.00	244.00
664	OUTLIER	36	115.11	64	118.82	414.00

TABLE E-9

PROCESS: TRICKLING FILTER - [illegible]
BOD EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OBS.	(2) LOG MEAN	(3) LOG STDEV	(4) EXP.VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5/4)	(7) STD. ERROR LOG MEAN(30)	(8) 99TH %ILE LOG MEAN(30)	(9) 95TH %ILE LOG MEAN(30)	(10) RATIO [illegible]
2	141	[illegible]	0.573	[illegible]	53.75	[illegible]	5.06	31.57	[illegible]	[illegible]
51	502	3.397	0.415	[illegible]	73.63	2.415	[illegible]	[illegible]	43.51	[illegible]
52	503	2.959	0.456	21.39	55.76	[illegible]	3.51	[illegible]	[illegible]	[illegible]
53	493	3.365	0.113	29.11	37.63	1.293	0.36	29.95	[illegible]	[illegible]
54	499	3.238	0.517	29.13	85.01	2.919	8.67	49.33	43.39	1.073
55	505	2.097	0.296	8.51	16.24	1.909	0.22	9.02	8.87	1.051
56	724	3.834	0.433	50.80	126.78	2.496	17.71	92.07	79.94	1.312
60	23	2.924	0.201	19.00	29.76	1.566	0.50	20.16	19.82	1.061
171	57	3.457	0.445	35.02	89.40	2.553	8.94	55.84	49.72	1.575
201	103	2.590	0.663	16.60	62.49	3.764	5.08	28.43	24.95	[illegible]
202	204	3.178	0.617	29.02	101.08	3.483	13.02	59.37	50.45	2.046
214	92	3.180	0.329	25.40	51.84	2.041	2.47	31.14	29.45	[illegible]
215	93	2.539	0.378	13.60	30.58	2.249	0.95	15.82	15.16	[illegible]
216	104	3.286	0.263	27.66	49.33	1.783	1.83	31.93	30.67	1.154
220	23	2.653	0.616	17.16	59.63	3.475	4.53	27.72	24.61	1.615
222	72	3.276	0.481	29.72	81.18	2.731	7.66	47.57	42.33	1.600
244	26	3.118	0.513	25.79	74.73	2.898	6.68	41.35	36.77	1.603
249	114	3.458	0.403	34.43	81.16	2.358	6.96	50.65	45.88	1.471
252	158	2.987	0.432	21.76	54.25	2.493	3.24	29.31	27.09	1.347
253	101	2.841	0.405	18.61	44.07	2.369	2.06	23.41	22.00	1.258
254	41	3.308	0.565	32.06	102.00	3.182	12.90	62.12	53.28	1.938
255	49	2.795	0.657	20.32	75.70	3.726	7.43	37.64	32.54	1.852
260	95	2.986	0.297	20.70	39.60	1.913	1.32	23.78	22.87	1.149
303	751	2.875	0.277	18.42	33.82	1.836	0.90	20.53	19.91	1.114
304	446	3.104	0.322	23.46	47.13	2.009	2.00	28.12	26.75	1.198
305	310	3.629	0.305	39.47	76.76	1.945	5.08	51.31	47.83	1.300
306	131	3.188	0.362	25.89	56.31	2.175	3.12	33.16	31.02	1.291
307	297	3.505	0.372	35.66	79.11	2.219	6.28	50.29	45.99	1.410
309	696	3.033	0.340	22.00	45.88	2.085	1.98	26.62	25.26	1.210
311	262	3.915	0.547	58.23	179.26	3.079	39.38	49.98	123.01	2.576
325	235	3.084	0.584	25.92	85.18	3.287	9.09	47.11	40.88	1.819
345	326	3.370	0.253	30.01	52.43	1.747	1.99	34.64	33.28	1.154
406	323	2.417	0.668	14.01	53.11	3.791	3.67	22.57	20.05	1.611
412	221	3.446	0.408	34.10	81.11	2.379	7.00	50.41	45.62	1.479
418	285	3.829	0.371	49.30	109.17	2.214	11.93	77.11	68.93	1.564
524	519	3.315	0.264	28.50	50.91	1.737	1.95	33.05	31.71	1.160
527	97	2.932	0.264	19.43	34.69	1.785	0.91	21.55	20.92	1.109
550 ✓	24	2.731	0.952	24.15	141.12	5.844	28.70	91.02	71.36	3.769
551	24	3.515	0.342	35.64	74.53	2.091	5.24	47.86	44.27	1.343
552	21	2.356	0.625	12.82	45.22	3.527	2.62	13.91	17.12	1.475
553	110	3.335	0.373	30.09	66.88	2.223	4.49	40.56	37.48	1.346
554	24	2.572	0.469	14.61	38.99	2.669	1.75	18.67	17.48	1.278
555	50	2.844	0.371	18.42	40.82	2.216	1.67	22.31	21.17	1.211
603	112	3.011	0.495	22.95	64.33	2.803	4.87	34.30	30.96	1.495
604	260	3.332	0.279	29.10	53.59	1.841	2.28	34.42	32.85	1.183
650	184	2.457	0.726	15.19	63.39	4.174	5.35	27.64	23.98	1.820
651	628	3.377	0.415	31.91	77.04	2.414	6.39	46.80	42.42	1.466
653	282	3.685	0.103	40.07	50.64	1.264	0.57	41.40	41.01	1.033
655	268	3.355	0.160	29.01	41.55	1.432	0.72	30.70	30.20	1.058
656	274	3.922	0.394	54.56	126.53	2.319	16.70	93.47	82.03	1.713
657	294	3.107	0.378	24.00	53.85	2.244	2.94	30.85	28.83	1.285
665	225	3.054	0.328	22.37	45.48	2.033	1.89	26.77	25.48	1.197
666	205	2.557	0.564	15.12	47.98	3.174	2.85	21.76	19.81	1.440
906	315	3.442	0.570	36.75	117.87	3.207	17.27	77.00	65.16	2.075
950	99	3.394	0.596	35.56	119.34	3.356	17.97	77.40	65.11	[illegible]
951	56	3.404	0.696	38.33	152.17	3.970	30.47	109.34	88.46	2.852
952	207	3.486	0.253	33.73	58.93	1.747	2.51	39.59	37.87	1.173
953	96	3.586	0.293	37.66	71.39	1.896	4.23	47.53	44.63	1.262
954	293	3.250	0.519	29.52	86.42	2.928	8.97	50.42	44.27	1.708
956	105	2.998	0.587	23.82	78.71	3.304	7.78	41.94	36.61	1.761
963	337	2.575	0.710	16.89	68.70	4.066	6.24	31.44	27.16	1.861
965	201	3.404	0.479	33.75	91.86	2.722	9.79	56.56	49.86	1.676
970	164	3.212	0.331	26.23	53.68	2.046	2.65	32.41	30.60	1.236
971	274	3.063	0.323	22.53	45.39	2.015	1.86	26.86	25.59	1.192
UNWEIGHTED AVERAGE	64	3.140	0.433	27.46	69.56	2.583	6.59	42.82	38.30	1.515
WEIGHTED AVERAGE	14760	3.193	0.397	28.69	68.17	2.398	6.15	43.01	38.30	1.441
MEDIAN									32.13	

Excluding facilities with ν ≥ 0.99: 550 ✓

UNWEIGHTED 63 37.78
WEIGHTED 14736 38.75
MEDIAN 31.71

TABLE E-10

PROCESS: TRICKLING FILTER - ROCK
TSS EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OBS.	(2) LOG MEAN	(3) LOG STDEV	(4) EXP.VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5)/(4)	(7) STD. ERROR LOG MEAN(30)	(8) 99TH %ILE LOG MEAN(30)	(9) 95TH %ILE LOG MEAN(30)	(10) RATIO (8)/(4)
2	140	2.647	0.553	16.44	51.18	3.112	3.22	23.95	21.75	1.457
51 √	52	3.057	0.906	32.08	175.82	5.481	43.71	133.93	113.97	4.175
52	503	3.288	0.350	27.92	59.33	2.124	3.38	35.80	33.48	1.282
53	23	3.432	0.429	33.93	84.17	2.480	7.77	52.05	45.72	1.534
54	106	3.160	0.781	31.97	145.41	4.549	28.63	98.68	79.07	3.087
55	106	2.236	0.436	10.29	25.86	2.513	0.74	12.02	11.51	1.168
56	727	3.260	0.492	29.39	81.87	2.786	7.87	47.72	42.33	1.624
60	.	.	.	.	.	.	.	.	.	.
171	75	3.345	0.502	32.15	91.26	2.839	9.87	55.14	48.38	1.715
201	103	3.083	0.274	22.65	41.26	1.822	1.33	25.74	24.83	1.137
202	187	3.363	0.567	33.91	108.29	3.194	14.56	67.83	57.86	2.000
214	84	3.024	0.373	22.06	49.11	2.226	2.43	27.71	26.05	1.256
215	93	2.718	0.461	16.85	44.32	2.631	2.24	22.06	20.53	1.309
216	69	2.938	0.367	20.20	44.41	2.198	1.96	24.77	23.43	1.226
220	23	3.227	0.426	27.59	67.97	2.463	5.05	39.35	35.89	1.426
222	37	3.504	0.435	36.54	91.52	2.505	9.25	58.10	51.76	1.590
244	27	2.898	0.663	22.60	85.08	3.765	9.41	44.53	38.08	1.971
249	105	3.309	0.375	29.36	65.57	2.233	4.34	39.47	36.49	1.344
252	312	3.353	0.197	29.15	45.24	1.552	1.12	31.76	30.99	1.090
253	103	2.359	0.537	12.22	36.96	3.026	1.66	16.09	14.95	1.317
254	43	3.032	0.821	29.04	140.33	4.833	27.01	91.97	73.47	3.168
255	49	2.655	0.820	19.91	96.05	4.825	12.65	49.38	40.72	2.481
260	94	2.124	0.489	9.42	26.11	2.770	0.80	11.28	10.74	1.197
303	757	2.894	0.395	19.53	45.34	2.322	2.15	24.53	23.06	1.256
304	446	2.745	0.438	17.13	43.17	2.520	2.07	21.95	20.53	1.281
305	310	3.118	0.274	23.46	42.75	1.823	1.43	26.78	25.80	1.142
306	131	3.281	0.197	27.12	42.08	1.552	0.97	29.37	28.71	1.083
307	297	3.479	0.420	35.42	86.34	2.438	8.08	54.24	48.71	1.532
309	694	3.009	0.406	22.01	52.17	2.371	2.89	28.74	26.76	1.306
311	262	3.454	0.421	34.54	84.25	2.439	7.70	52.48	47.20	1.519
325	233	2.846	0.529	19.80	59.05	2.982	4.22	29.64	26.74	1.497
345	326	3.330	0.266	28.94	51.88	1.793	2.04	33.69	32.30	1.164
406	323	1.790	0.892	8.92	47.86	5.367	3.22	16.42	14.21	1.842
412	83	3.229	0.530	29.06	86.78	2.986	9.12	50.30	44.06	1.731
418	303	3.201	0.766	32.94	146.42	4.445	28.89	100.26	80.46	3.044
524	519	3.134	0.587	27.29	90.22	3.306	10.22	51.11	44.10	1.873
527	94	2.647	0.254	14.57	25.49	1.749	0.47	15.67	15.35	1.075
550 √	23	2.292	1.081	17.74	122.78	6.921	23.27	71.95	56.01	4.056
551	24	3.185	0.531	27.83	83.34	2.995	8.42	47.45	41.68	1.705
552	21	2.356	0.571	12.42	39.89	3.213	1.98	17.03	15.67	1.371
553	117	2.804	0.655	20.46	75.97	3.712	7.48	37.89	32.77	1.852
554	24	2.630	0.561	16.24	51.30	3.158	3.25	23.83	21.60	1.467
555	50	2.701	0.392	16.08	37.13	2.309	1.43	19.42	18.44	1.208
603	114	2.951	0.757	25.48	111.61	4.381	16.74	64.48	53.01	2.531
604	261	3.103	0.380	23.93	53.99	2.256	2.97	30.85	28.81	1.289
650	182	3.082	0.636	26.67	95.84	3.593	11.81	54.18	46.09	2.031
651	635	3.201	0.438	27.02	68.11	2.521	5.15	39.01	35.48	1.444
653	481	3.693	0.099	40.37	50.61	1.254	0.54	41.62	41.25	1.031
655	285	3.245	0.185	26.11	39.52	1.513	0.79	27.96	27.42	1.071
656	276	3.245	0.561	30.03	94.88	3.160	11.14	55.97	48.35	1.864
657	512	1.806	0.870	8.89	46.20	5.200	2.98	15.82	13.78	1.781
665	417	2.863	0.447	19.36	49.62	2.563	2.76	25.79	23.90	1.332
666	253	2.646	0.433	15.48	38.63	2.496	1.64	19.31	18.18	1.248
906	315	3.164	0.550	27.53	85.24	3.096	8.92	48.32	42.21	1.755
950	18	3.413	0.655	37.61	139.57	3.711	25.24	96.43	79.13	2.564
951	.	.	.	.	.	.	.	.	.	.
952	.	.	.	.	.	.	.	.	.	.
953	.	.	.	.	.	.	.	.	.	.
954	13	3.238	0.464	28.37	75.07	2.646	6.44	43.37	38.96	1.529
956	.	.	.	.	.	.	.	.	.	.
963 √	348	2.606	1.167	26.76	205.42	7.678	69.31	188.25	140.77	7.036
965	24	2.730	0.774	20.67	92.95	4.497	11.67	47.87	39.87	2.316
970	.	.	.	.	.	.	.	.	.	.
971	275	2.709	0.406	16.31	38.65	2.370	1.59	20.00	18.92	1.227
UNWEIGHTED AVERAGE	58	2.684	0.472	21.84	66.52	2.801	7.94	40.33	38.50	1.619
WEIGHTED AVERAGE	12507	2.991	0.486	24.34	68.17	2.909	7.43	41.66	36.56	1.678
MEDIAN									34.48	

√Excluding facilities with ν>0.99: √51, 550, 963

UNWEIGHTED	55	35.14
WEIGHTED	12084	33.23
MEDIAN		32.77

TABLE E-11

PROCESS: ACTIVATED SLUDGE - CONV.
BOD EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OBS.	(2) LOG MEAN	(3) LOG STDEV	(4) EXP.VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5)/(4)	(7) STD. ERROR LOG MEAN [illegible]	(8) 99TH %ILE LOG MEAN [illegible]	(9) 95TH %ILE LOG MEAN [illegible]	[illegible]
6	53	2.150	0.895	12.94	69.79	5.393	[illegible]	[illegible]	24.22	[illegible]
15	118	2.605	0.288	14.10	26.48	1.878	0.57	15.44	[illegible]	[illegible]
18	58	2.911	0.397	19.88	46.33	2.331	2.25	25.12	23.00	[illegible]
19	74	2.041	0.464	8.58	22.70	2.647	0.59	9.95	9.54	[illegible]
28 ✓	389	2.225	1.202	19.06	152.27	7.989	39.23	110.46	83.59	[illegible]
29	272	2.698	0.547	17.24	53.06	3.077	3.45	25.28	22.91	[illegible]
32	475	2.730	0.335	16.22	33.49	2.065	1.04	18.65	17.94	[illegible]
33	179	2.449	0.359	16.75	85.75	5.119	10.22	40.56	33.56	[illegible]
35	725	2.721	0.603	18.23	61.89	3.395	4.85	29.52	26.20	[illegible]
39	425	2.007	0.447	8.22	21.09	2.564	0.50	9.39	9.04	1.141
40	650	0.888	0.887	3.60	17.20	5.329	0.50	4.81	[illegible]	[illegible]
105	247	2.011	0.454	8.28	21.50	2.596	0.52	9.50	9.14	[illegible]
107	692	1.693	0.729	7.09	29.70	4.189	1.17	9.83	9.02	[illegible]
108	517	3.553	0.606	41.97	143.44	3.417	26.09	102.76	84.69	2.443
109	706	3.149	0.575	27.51	89.08	3.238	9.90	50.57	43.79	1.838
110	258	2.252	0.562	11.13	35.18	3.162	1.53	14.70	13.65	1.321
117	462	2.387	0.387	11.73	26.81	2.286	0.74	13.45	12.95	1.147
118	502	2.970	0.805	26.95	127.15	4.719	22.06	78.35	63.24	2.909
128	697	2.644	0.697	17.95	71.42	3.980	6.72	33.60	29.00	1.872
139	697	1.735	0.407	6.16	14.64	2.376	0.23	6.69	6.53	1.036
141	701	2.617	0.725	17.81	74.12	4.162	7.30	34.32	29.32	1.950
144	366	2.275	0.559	11.38	35.82	3.148	1.59	15.07	13.99	1.325
146	486	2.265	0.613	11.62	40.14	3.455	2.05	16.39	14.99	1.411
150	730	2.260	0.681	12.08	46.81	3.875	2.87	18.76	16.80	1.553
159	699	2.626	0.668	17.27	65.58	3.797	5.60	30.33	26.49	1.756
160	637	2.346	0.667	13.05	49.40	3.786	3.18	20.45	18.27	1.567
161 ✓	709	2.974	0.868	28.52	147.84	5.184	30.47	99.51	78.64	3.439
172	305	3.410	0.661	37.65	141.19	3.750	25.90	97.99	80.25	2.603
173	435	1.988	0.776	9.86	44.49	4.511	2.68	16.10	14.26	1.632
175	515	2.188	0.679	11.23	43.40	3.865	2.46	16.97	15.29	1.511
179	593	3.162	0.809	32.76	155.58	4.749	33.08	109.82	87.17	3.353
193	419	1.536	0.540	5.38	16.34	3.040	0.33	6.14	5.91	1.141
217	103	2.904	0.770	24.55	109.73	4.470	16.25	62.40	51.27	2.542
218	140	2.165	0.901	13.09	71.20	5.440	7.15	29.76	24.86	2.274
225	638	2.579	0.845	18.85	94.42	5.010	12.33	47.57	39.13	2.524
227	695	1.917	0.730	8.87	37.25	4.198	1.85	13.18	11.91	1.485
229	198	2.264	0.935	14.91	85.10	5.709	10.36	39.05	31.95	2.617
233	92	2.220	0.350	9.79	20.80	2.125	0.42	10.76	10.47	1.099
235	95	2.546	0.757	17.02	74.52	4.378	7.46	34.40	29.29	2.021
312	756	1.558	0.699	6.07	24.23	3.994	0.77	7.87	7.34	1.297
314	534	1.831	0.668	7.80	29.57	3.791	1.14	10.45	9.67	1.340
315	707	2.368	0.670	13.36	50.82	3.804	3.37	21.20	18.90	1.587
316	511	2.662	0.409	15.57	37.11	2.384	1.47	18.99	17.98	1.220
317	522	1.700	0.654	6.78	25.12	3.704	0.82	8.68	8.12	1.281
319	759	2.756	0.869	22.97	119.28	5.193	19.84	69.20	55.61	3.013
320	714	1.045	0.709	3.65	14.83	4.057	0.29	4.33	4.13	1.185
321	748	1.890	0.556	7.72	24.16	3.129	0.72	9.40	8.91	1.217
322	761	2.741	0.610	18.67	64.22	3.439	5.24	30.88	27.29	1.654
324	682	2.610	0.292	14.19	26.84	1.892	0.60	15.58	15.17	1.098
404	307	2.504	0.463	13.61	35.95	2.641	1.48	17.05	16.04	1.253
421	327	3.063	0.431	23.48	58.42	2.488	3.75	32.23	29.66	1.372
422	304	2.911	0.609	22.11	75.86	3.432	7.31	39.14	34.13	1.770
423	321	1.714	0.742	7.31	31.24	4.275	1.30	10.35	9.45	1.41
428	328	2.240	0.539	10.86	33.00	3.037	1.33	13.96	13.05	1.28
432	661	3.131	0.486	25.78	71.13	2.759	5.91	39.55	35.50	1.534
433	677	1.780	0.900	8.89	48.33	5.434	3.30	16.57	14.32	1.363
436	303	2.671	0.631	17.64	62.84	3.562	5.06	29.44	25.97	1.669
438	261	3.103	0.345	23.63	49.73	2.105	2.35	29.11	27.49	1.232
440	311	2.821	0.195	17.12	26.46	1.545	0.38	18.00	17.74	1.052
518	430	2.854	0.478	19.46	52.91	2.719	3.25	27.02	24.80	1.389
519	276	1.905	0.503	7.62	21.70	2.847	0.56	8.93	8.54	1.171
520	178	1.958	0.959	11.22	66.11	5.894	6.32	25.93	21.60	2.312
556	212	2.687	0.358	15.66	33.85	2.162	1.12	18.27	17.50	1.167
607	144	2.740	0.785	21.08	96.44	4.575	12.61	50.46	41.32	2.344
671	257	3.303	0.624	33.05	116.43	3.523	17.34	73.44	61.56	2.222
672	252	2.853	0.604	20.81	70.89	3.407	6.37	35.64	31.28	1.713
UNWEIGHTED AVERAGE	66	2.416	0.628	15.84	58.67	3.670	6.46	30.89	26.46	1.749
WEIGHTED AVERAGE	29045	2.375	0.641	15.59	58.71	3.729	6.60	30.98	26.46	1.749
MEDIAN									18.59	

****EXCLUDING FACILITIES WITH V> .99: ✓ 28, 161

UNWEIGHTED	64	24.75
WEIGHTED	24947	24.34
MEDIAN		18.13

TABLE E-12

PROCESS: ACTIVATED SLUDGE - CONV.
TSS EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OBS.	(2) LOG MEAN	(3) LOG STDEV	(4) EXP. VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5)/(4)	(7) STD. ERROR LOG MEAN(30)	(8) 99TH %ILE LOG MEAN(30)	(9) 95TH %ILE LOG MEAN(30)	(10) RATIO (8)/(4)
3	114	2.563	0.653	16.06	59.36	3.697	4.59	28.83	23.52	[illegible]
15	123	2.336	0.724	23.29	96.78	4.155	12.45	52.29	[illegible]	[illegible]
16	59	3.234	0.771	34.18	153.17	4.481	31.67	107.97	[illegible]	[illegible]
19	144	2.501	0.514	13.92	40.42	2.904	1.96	18.47	17.13	[illegible]
28 √	399	2.011	1.222	15.76	128.80	8.170	28.58	82.36	62.73	[illegible]
29	273	2.949	0.635	23.34	83.74	3.588	9.01	44.33	38.16	1.899
32	477	2.564	0.560	15.20	47.94	3.154	2.64	21.32	19.37	1.403
33	186	2.608	0.824	19.06	92.51	4.854	11.75	46.43	38.38	2.437
35	722	3.103	0.806	30.81	145.75	4.730	29.00	98.40	78.57	3.197
39	426	1.791	0.531	6.70	20.63	2.990	0.52	7.87	7.75	1.174
40	635	1.884	0.907	9.93	54.49	5.487	4.20	19.72	16.84	1.985
105	257	2.320	0.483	11.44	31.39	2.744	1.15	14.11	13.33	1.234
107	590	1.561	1.016	7.98	50.80	6.365	3.83	16.92	14.29	2.119
108	517	3.397	0.697	38.10	151.71	3.982	33.31	108.73	97.96	2.853
109	718	3.252	0.687	32.73	128.13	3.915	21.54	82.92	68.16	2.533
110	258	2.821	0.576	19.83	64.28	3.242	5.16	31.84	28.31	1.606
117	462	1.795	0.546	6.99	21.50	3.077	0.57	8.31	7.92	1.189
118	507	2.832	0.677	21.36	82.22	3.850	8.83	41.94	35.89	1.964
128 √	702	3.208	0.814	34.44	164.85	4.786	37.20	121.12	95.64	3.517
139	700	1.876	0.670	8.17	31.10	3.806	1.26	11.11	10.25	1.360
141	702	1.521	0.557	5.34	16.77	3.137	0.35	6.15	5.92	1.151
144	366	2.188	0.791	12.19	56.31	4.620	4.31	22.23	19.28	1.824
146	486	1.635	0.748	6.79	29.32	4.321	1.15	9.47	8.68	1.396
150	725	2.359	0.567	12.43	39.65	3.190	1.95	16.98	15.64	1.366
159	712	2.101	0.800	11.25	52.67	4.680	3.78	20.06	17.47	1.782
160	631	2.316	0.836	14.37	71.12	4.948	6.97	30.62	25.85	2.131
161 √	715	3.275	1.075	47.10	323.38	6.866	160.8	421.68	311.55	8.953
172	305	3.255	0.639	31.76	114.80	3.613	16.97	71.31	59.69	2.244
173	482	2.231	0.736	12.20	51.66	4.235	3.56	20.49	18.06	1.680
175	515	2.235	0.578	11.05	35.98	3.256	1.62	14.82	13.71	1.341
179 √	632	3.400	0.808	41.52	196.87	4.741	52.95	164.88	128.62	3.971
193	419	1.944	0.488	7.87	21.77	2.767	0.55	9.16	8.79	1.164
217 √	95	3.019	0.839	29.11	144.60	4.967	28.86	96.35	76.58	3.310
218	273	1.893	0.870	9.69	50.36	5.198	3.54	17.93	15.51	1.851
225 √	636	3.152	1.076	41.70	286.74	6.876	126.5	336.47	249.77	8.069
227	718	1.773	0.973	9.46	56.83	6.010	4.70	20.40	17.18	2.158
229	200	2.732	0.837	21.81	108.01	4.952	16.09	59.30	48.29	2.719
233	92	2.250	0.929	14.60	82.56	5.655	9.72	37.26	30.60	2.552
235	95	1.756	0.770	7.79	34.83	4.473	1.64	11.60	10.48	1.490
312	756	1.638	0.819	7.19	34.64	4.818	1.64	11.02	9.90	1.533
314	533	2.172	0.697	11.19	44.54	3.979	2.61	17.28	15.49	1.544
315	712	1.855	0.822	8.96	43.38	4.842	2.58	14.98	13.21	1.672
316	504	2.451	0.463	12.92	34.14	2.642	1.33	16.02	15.11	1.240
317	534	2.402	0.778	14.95	67.68	4.526	6.20	29.39	25.14	1.965
319 √	755	3.129	1.107	42.17	301.43	7.149	142.7	374.64	276.90	8.885
320	710	2.042	0.925	11.81	66.43	5.623	6.29	26.46	22.15	2.240
321	761	1.903	0.712	8.64	35.26	4.080	1.65	12.48	11.35	1.444
322 √	761	2.792	0.974	26.22	157.79	6.018	36.23	110.64	85.82	4.220
324	696	2.575	0.363	14.03	30.64	2.183	0.93	16.19	15.56	1.154
404	319	2.266	0.519	11.03	32.29	2.928	1.25	13.95	13.09	1.265
421	327	2.869	0.694	22.41	88.73	3.959	10.35	46.54	39.45	2.076
422	333	2.468	0.882	17.40	92.10	5.293	11.89	45.10	36.96	2.591
423	323	1.833	0.780	8.48	38.52	4.543	2.01	13.16	11.78	1.552
428	328	1.268	0.870	5.19	27.00	5.201	1.02	7.56	6.86	1.457
432	661	2.906	0.622	22.17	77.78	3.508	7.73	40.16	34.88	1.812
433	643	2.129	0.765	11.26	49.94	4.434	3.36	19.09	16.79	1.695
436	304	2.670	0.441	15.91	40.31	2.534	1.81	20.12	18.88	1.265
438	272	2.890	0.494	20.32	56.81	2.796	3.80	29.16	26.56	1.435
440	311	2.794	0.194	16.65	25.69	1.542	0.35	17.48	17.24	1.050
518	445	1.947	0.685	8.86	34.56	3.901	1.57	12.51	11.44	1.412
519	286	2.256	0.615	11.53	39.97	3.466	2.03	16.27	14.88	1.411
520 √	166	1.317	1.409	10.07	99.44	9.875	21.21	59.48	44.96	5.907
556	214	2.423	0.470	12.59	33.68	2.675	1.30	15.63	14.74	1.241
607	359	2.553	0.784	17.46	79.79	4.570	8.63	37.57	31.66	2.151
671 √	319	2.708	0.980	24.24	147.04	6.065	31.55	97.75	76.14	4.032
672	311	3.007	0.549	23.51	72.67	3.091	6.48	38.62	34.16	1.642
UNWEIGHTED AVERAGE	66	2.416	0.737	17.50	79.94	4.375	15.32	53.18	42.69	2.351
WEIGHTED AVERAGE	29811	2.399	0.752	17.84	85.08	4.467	18.77	61.59	48.73	2.492
MEDIAN									19.58	

***EXCLUDING FACILITIES WITH ν> .99: √28 128 161 179 217 225
319 322 520 671 √

UNWEIGHTED	56	25.16
WEIGHTED	24631	23.72
MEDIAN		17.21

TABLE E-13

PROCESS: STABILIZATION POND
BOD EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OBS.	(2) LOG MEAN	(3) LOG STDD.	(4) EXP.VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5)/(4)	(7) STD. ERROR LOG MEAN(30)	(8) 99TH %ILE LOG MEAN 30)	(9) 95TH %ILE LOG MEAN 30)	(10) RATIO (8)/(4)
59	23	3.033	0.473	24.59	[illegible]	[illegible]	5.17	[illegible]	[illegible]	1.490
62	.	.	.	.	.	.	.	.	.	.
63	.	.	.	.	.	.	.	.	.	.
65	.	.	.	.	.	.	.	.	.	.
106	45	3.056	0.503	24.09	68.51	2.843	5.56	37.06	33.25	1.538
111	36	2.520	0.553	14.52	45.60	3.140	2.57	20.50	18.74	1.412
112	63	3.059	0.585	25.28	83.25	3.293	8.69	45.53	39.57	1.801
122	34	3.250	0.551	30.00	93.01	3.101	10.63	54.[illegible]	47.49	1.826
123	40	2.298	0.933	15.39	87.57	5.691	10.96	40.93	33.42	2.660
124	44	2.952	0.663	23.83	89.59	3.759	10.43	48.14	41.00	2.020
131	18	2.896	0.317	19.03	37.87	1.989	1.27	22.00	21.13	1.156
132	43	3.162	0.527	27.14	80.57	2.969	7.84	45.41	40.04	1.673
133	51	2.759	0.526	22.14	65.73	2.969	5.22	34.31	30.73	1.549
134	35	2.576	0.533	15.15	45.50	3.004	2.51	21.01	19.28	1.387
136	32	3.129	0.335	24.17	49.92	2.065	2.32	29.57	27.99	1.224
137	47	2.568	0.696	16.61	65.96	3.972	5.73	29.95	26.03	1.803
153	27	1.878	0.786	8.91	40.83	4.583	2.26	14.18	12.63	1.591
156	76	2.582	0.664	16.49	62.13	3.768	5.02	28.18	24.74	1.709
165	54	2.616	0.672	17.14	65.46	3.819	5.59	30.17	26.34	1.760
166	20	2.321	0.536	11.77	35.56	3.023	1.54	15.33	14.30	1.305
167	28	2.969	0.557	22.75	71.39	3.138	6.29	37.40	33.10	1.644
168	35	2.896	0.631	22.09	78.73	3.565	7.95	40.61	35.17	1.839
169	81	2.603	0.795	18.53	86.10	4.647	10.08	42.02	35.12	2.268
176	20	2.327	0.749	13.55	58.60	4.323	4.60	24.27	21.12	1.791
186	.	.	.	.	.	.	.	.	.	.
187	.	.	.	.	.	.	.	.	.	.
337	104	3.624	0.423	40.98	100.34	2.449	10.95	66.49	58.99	1.623
339	.	.	.	.	.	.	.	.	.	.
340	.	.	.	.	.	.	.	.	.	.
341	.	.	.	.	.	.	.	.	.	.
342	294	2.553	0.632	15.69	56.07	3.574	4.04	25.09	22.33	1.599
402	50	2.597	0.953	21.14	123.73	5.853	22.07	72.57	57.45	3.433
654	46	3.112	0.408	24.42	58.15	2.381	3.60	32.81	30.35	1.344
658✓	48	4.043	0.693	72.49	286.55	3.953	108	324.04	250.09	4.470
659	40	2.793	0.559	19.09	60.09	3.148	4.46	29.48	26.43	1.544
660	44	3.084	0.661	27.18	101.87	3.748	13.48	58.58	49.35	2.155
664	37	3.672	0.461	43.74	115.12	2.632	15.09	78.91	68.57	1.804
UNWEIGHTED AVERAGE	29	2.248	0.470	18.32	61.64	2.706	8.21	37.46	40.62	1.444
WEIGHTED AVERAGE	1515	2.857	0.612	23.18	78.91	3.512	10.28	47.13	40.09	1.851
MEDIAN									33.10	

✓ EXCLUDING FACILITIES WITH v> .99: ✓658

UNWEIGHTED	28	33.13
WEIGHTED	1467	33.22
MEDIAN		31.92

TABLE E-14

PROCESS: STABILIZATION POND
TSS EFFLUENT DATA
LOG TRANSFORM

FACILITY NUMBER	(1) # OF OTS.	(2) LOG MEAN	(3) LOG STDEV	(4) EXP.VAL. LOG MEAN	(5) 99TH %ILE	(6) RATIO (5)/(4)	(7) STD. ERROR LOG MEAN(30)	(8) 99TH %ILE LOG MEAN(30)	(9) 95TH %ILE LOG MEAN(30)	(10) RATIO (8)/(4)
59✓	18	3.352	0.824	40.12	194.86	4.857	52.14	161.41	125.39	4.023
62	.	.	.	.	.	.	.	.	.	.
63	.	.	.	.	.	.	.	.	.	.
65	.	.	.	.	.	.	.	.	.	.
106	45	3.476	0.619	39.16	136.80	3.493	23.88	94.80	78.44	2.420
111	36	2.862	0.660	21.75	81.38	3.742	9.60	41.78	35.89	1.921
112✓	64	3.558	0.738	46.07	195.76	4.249	51.17	165.29	130.24	3.588
122✓	34	3.092	0.839	31.32	155.58	4.967	33.41	109.15	86.27	3.485
123✓	40	2.754	1.126	29.61	216.55	7.314	74.63	203.51	152.38	6.873
124✓	44	2.833	1.093	30.87	216.72	7.021	73.03	201.04	151.01	6.513
131	18	3.540	0.651	42.59	156.94	3.685	31.86	116.83	95.00	2.743
132✓	43	3.659	0.703	49.70	199.60	4.016	52.56	172.17	136.16	3.464
133✓	51	3.606	0.925	56.46	317.44	5.623	143.5	390.89	292.57	6.924
134	35	3.337	0.563	32.95	104.32	3.166	13.47	64.34	55.11	1.953
136	31	3.506	0.667	41.60	157.44	3.785	32.27	116.79	94.69	2.807
137	47	2.872	0.680	22.26	86.20	3.872	9.72	44.92	38.26	2.018
153	27	2.853	0.801	23.91	112.17	4.691	17.15	63.87	52.12	2.671
156	71	3.231	0.722	32.83	136.05	4.144	24.58	90.11	73.27	2.745
165	53	3.168	0.658	29.51	110.02	3.728	15.70	66.09	55.34	2.240
166	20	2.937	0.797	25.90	120.75	4.662	19.85	72.14	58.55	2.785
167	28	4.084	0.382	63.87	144.51	2.263	21.33	113.56	98.95	1.778
168✓	35	2.917	0.882	27.28	144.37	5.292	29.21	95.33	75.33	3.494
169✓	81	3.276	0.983	42.91	261.49	6.094	99.94	275.77	207.31	6.427
176✓	20	2.618	0.953	21.57	126.09	5.846	22.91	74.96	59.26	3.475
186	.	.	.	.	.	.	.	.	.	.
187	.	.	.	.	.	.	.	.	.	.
337	104	4.033	0.364	60.31	131.79	2.185	17.17	100.31	88.55	1.663
339	.	.	.	.	.	.	.	.	.	.
340	.	.	.	.	.	.	.	.	.	.
341	.	.	.	.	.	.	.	.	.	.
342	298	2.428	0.525	13.01	38.51	2.961	1.79	17.18	15.95	1.321
402✓	52	2.789	1.125	30.62	223.66	7.303	79.55	215.97	161.48	7.052
654	46	3.655	0.457	42.94	112.23	2.613	14.29	76.23	66.45	1.775
658✓	48	3.944	1.051	89.71	597.37	6.659	540.6	1349.3	978.98	15.04
659✓	40	3.645	0.786	52.16	239.15	4.585	77.57	232.90	179.77	4.465
660✓	44	4.032	0.897	84.29	455.78	5.407	292.7	766.30	565.80	9.091
664✓	36	4.400	0.791	111.4	514.53	4.621	359.7	949.37	703.00	8.525
UNWEIGHTED AVERAGE	29	2.607	0.602	33.42	153.73	3.590	60.39	174.12	169.38	3.332
WEIGHTED AVERAGE	1509	3.212	0.719	38.85	173.17	4.271	66.68	194.21	148.54 94.69	3.838

EXCLUDING FACILITIES WITH ν > .99 ✓ 59 112 122 123 124 132 133 168 169 176 402 658 659 660 664 ✓

UNWEIGHTED	14	64.76
WEIGHTED	859	50.87
MEDIAN		62.50

Table E-15

EXPECTED MEDIAN BOD_5 AND SS EFFLUENT VALUES BY TREATMENT PROCESS TYPE, ASSUMED NORMAL DISTRIBUTION

	BOD_5 (mg/l)			SS (mg/l)		
Process Category	Median of $\mu_{\bar{x}}$ (a)	Median of $\sigma_{\bar{x}_{30}}$ (b)	P_{MED} (c)	Median of μ_x	Median of $\sigma_{\bar{x}_{30}}$	P_{MED}
Trickling Filter-Rock	26.03	5.88	35.70	25.25	6.28	35.58
Trickling Filter-Plastic	18.98	5.43	28.00	19.36	5.11	27.77
Activated Sludge Conventional	14.79	5.08	23.15	14.30	6.89	25.63
Activated Sludge Contact Stab.	12.63	5.54	21.74	13.80	6.24	24.06
Activated Sludge Extended Aer.	7.20	3.03	12.18	9.78	3.42	15.41
R.B.C.	16.99	6.26	27.29	15.15	4.50	22.55
Oxidation Ditch	8.40	3.98	14.95	12.26	5.98	22.10
Stabilization Pond	22.71	8.04	35.94	39.51	17.10	67.64

(a) μ_x = Overall facility mean

(b) $\sigma_{\bar{x}_{30}}$ = Standard deviation of the overall facility 30-day mean

(c) $P_{MED} = \mu_x + (1.645\ \sigma_{\bar{x}_{30}})$

APPENDIX F

TECHNICAL DATA SUMMARIES
FOR
PROCESSES AND FACILITIES
IN TREATMENT EQUIVALENT TO SECONDARY TREATMENT CATEGORY

TABLE F-1

SUMMARY TABLE
RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
94 FACILITIES					
UNWEIGHTED AVG.	247	28.00	326	27.94	43.78
WEIGHTED AVG.		29.66		29.83	46.49
MEDIAN	205	24.52	318	24.26	36.04
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
74 FACILITIES					
UNWEIGHTED AVG.	235	30.44	321	30.36	47.28
WEIGHTED AVG.		31.86		32.02	48.51
MEDIAN	206	27.18	324	26.81	40.35
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
64 FACILITIES					
UNWEIGHTED AVG.	231	27.25	315	27.18	42.13
WEIGHTED AVG.		28.56		28.37	42.01
MEDIAN	203	26.03	296	25.84	37.42
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
48 FACILITIES					
UNWEIGHTED AVG.	228	30.82	316	30.75	47.79
WEIGHTED AVG.		32.62		32.17	47.60
MEDIAN	206	29.37	310	29.45	44.46

TABLE F-2

SUMMARY TABLE
RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
94 FACILITIES					
UNWEIGHTED AVG.	247	28.00	336	27.96	60.82
WEIGHTED AVG.		29.66		29.82	63.98
MEDIAN	205	24.52	320	24.40	51.38
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
74 FACILITIES					
UNWEIGHTED AVG.	235	30.44	330	30.39	65.96
WEIGHTED AVG.		31.86		32.06	67.34
MEDIAN	206	27.18	320	27.11	54.93
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
64 FACILITIES					
UNWEIGHTED AVG.	231	27.25	324	27.19	59.94
WEIGHTED AVG.		28.56		28.41	59.49
MEDIAN	203	26.03	309	25.90	52.50
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
48 FACILITIES					
UNWEIGHTED AVG.	228	30.82	327	30.74	69.18
WEIGHTED AVG.		32.62		32.18	67.85
MEDIAN	206	29.37	314	29.40	63.68

TABLE F-3

SUMMARY TABLE
RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
94 FACILITIES					
UNWEIGHTED AVG.	225	25.71	290	25.44	42.49
WEIGHTED AVG.		25.62		25.90	38.96
MEDIAN	126	22.61	209	22.43	34.53
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
74 FACILITIES					
UNWEIGHTED AVG.	205	27.81	274	27.46	46.67
WEIGHTED AVG.		28.29		28.15	42.19
MEDIAN	116	26.14	195	25.91	40.14
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
64 FACILITIES					
UNWEIGHTED AVG.	196	24.88	259	24.49	43.18
WEIGHTED AVG.		24.08		23.97	36.47
MEDIAN	106	25.25	181	25.60	37.68
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
39 FACILITIES					
UNWEIGHTED AVG.	218	29.78	281	29.19	54.18
WEIGHTED AVG.		27.73		27.94	43.02
MEDIAN	131	27.70	205	27.96	45.62

TABLE F-4

SUMMARY TABLE
RANK ORDER OF ROCK MEDIA TRICKLING FILTER FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
94 FACILITIES					
UNWEIGHTED AVG.	225	25.71	298	25.77	67.31
WEIGHTED AVG.		25.62		25.93	62.09
MEDIAN	126	22.61	221	22.51	48.00
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
74 FACILITIES					
UNWEIGHTED AVG.	205	27.81	280	27.87	74.05
WEIGHTED AVG.		28.29		28.20	66.87
MEDIAN	116	26.14	204	26.33	55.24
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
64 FACILITIES					
UNWEIGHTED AVG.	196	24.88	265	24.96	70.66
WEIGHTED AVG.		24.08		24.04	59.72
MEDIAN	106	25.25	194	25.25	50.00
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
39 FACILITIES					
UNWEIGHTED AVG.	218	29.78	289	29.90	90.87
WEIGHTED AVG.		27.73		27.98	71.75
MEDIAN	131	27.70	219	27.93	66.80

TABLE F-5

SUMMARY TABLE
RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
22 FACILITIES					
UNWEIGHTED AVG.	316	28.47	410	28.63	49.55
WEIGHTED AVG.		25.23		25.48	41.39
MEDIAN	286	24.13	373	24.35	38.71
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
14 FACILITIES					
UNWEIGHTED AVG.	217	29.95	308	30.11	56.14
WEIGHTED AVG.		26.38		27.06	48.42
MEDIAN	197	24.29	299	24.44	40.33
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
10 FACILITIES					
UNWEIGHTED AVG.	214	20.02	305	20.07	33.96
WEIGHTED AVG.		16.80		17.07	30.19
MEDIAN	189	17.68	269	17.58	29.40
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
4 FACILITIES					
UNWEIGHTED AVG.	138	26.83	211	26.87	49.95
WEIGHTED AVG.		24.39		24.82	48.91
MEDIAN	144	27.46	222	27.52	51.96

TABLE F-6

SUMMARY TABLE
RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
22 FACILITIES					
UNWEIGHTED AVG.	316	28.47	418	28.57	81.25
WEIGHTED AVG.		25.23		25.41	61.32
MEDIAN	286	24.13	385	24.26	48.85
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
14 FACILITIES					
UNWEIGHTED AVG.	217	29.95	312	30.09	98.95
WEIGHTED AVG.		26.38		27.01	78.34
MEDIAN	197	24.29	305	24.39	53.76
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
10 FACILITIES					
UNWEIGHTED AVG.	214	20.02	308	20.04	52.11
WEIGHTED AVG.		16.80		17.03	46.11
MEDIAN	189	17.68	274	17.73	35.03
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
4 FACILITIES					
UNWEIGHTED AVG.	138	26.83	217	26.75	83.89
WEIGHTED AVG.		24.39		24.78	82.05
MEDIAN	144	27.46	226	27.57	68.77

TABLE F-7

SUMMARY TABLE
RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
22 FACILITIES					
UNWEIGHTED AVG.	328	24.59	414	24.84	40.95
WEIGHTED AVG.		21.38		21.91	36.18
MEDIAN	291	20.23	386	20.05	28.53
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
14 FACILITIES					
UNWEIGHTED AVG.	231	27.97	322	28.34	48.30
WEIGHTED AVG.		26.57		26.89	46.17
MEDIAN	209	20.93	320	21.24	33.83
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
10 FACILITIES					
UNWEIGHTED AVG.	238	17.87	332	18.16	30.64
WEIGHTED AVG.		17.07		17.18	30.99
MEDIAN	204	19.61	308	19.70	27.73
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
3 FACILITIES					
UNWEIGHTED AVG.	391	22.16	432	22.76	44.20
WEIGHTED AVG.		19.73		20.77	42.48
MEDIAN	256	22.49	328	22.52	46.44

TABLE F-8

SUMMARY TABLE
RANK ORDER OF PLASTIC MEDIA TRICKLING FILTER FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
22 FACILITIES					
UNWEIGHTED AVG.	328	24.59	421	24.65	59.85
WEIGHTED AVG.		21.38		21.78	52.99
MEDIAN	291	20.23	401	20.17	52.94
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
14 FACILITIES					
UNWEIGHTED AVG.	231	27.97	324	28.07	68.61
WEIGHTED AVG.		26.57		26.69	64.97
MEDIAN	209	20.93	318	21.09	55.85
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
10 FACILITIES					
UNWEIGHTED AVG.	238	17.87	333	18.03	46.71
WEIGHTED AVG.		17.07		17.01	47.60
MEDIAN	204	19.61	310	19.66	43.12
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
3 FACILITIES					
UNWEIGHTED AVG.	391	22.16	439	22.49	63.19
WEIGHTED AVG.		19.73		20.46	59.34
MEDIAN	256	22.49	323	22.56	64.59

TABLE F-9

SUMMARY TABLE
RANK ORDER OF OXIDATION DITCH FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
31 FACILITIES					
UNWEIGHTED AVG.	76	17.18	135	17.40	28.01
WEIGHTED AVG.		11.04		10.98	19.77
MEDIAN	68	8.52	121	8.65	16.77
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
30 FACILITIES					
UNWEIGHTED AVG.	72	17.55	127	17.78	28.61
WEIGHTED AVG.		11.52		11.47	20.72
MEDIAN	67	8.56	121	8.75	17.74
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	75	10.36	133	10.52	21.12
WEIGHTED AVG.		9.69		9.79	18.73
MEDIAN	69	8.40	123	8.44	16.20
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
5 FACILITIES					
UNWEIGHTED AVG.	41	21.77	72	22.75	46.81
WEIGHTED AVG.		20.06		20.62	44.43
MEDIAN	42	22.00	75	23.63	46.19

BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES
BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
31 FACILITIES					
UNWEIGHTED AVG.	76	17.18	142	17.26	40.07
WEIGHTED AVG.		11.04		11.09	32.96
MEDIAN	68	8.52	127	8.64	25.20
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
30 FACILITIES					
UNWEIGHTED AVG.	72	17.55	133	17.63	40.94
WEIGHTED AVG.		11.52		11.59	34.86
MEDIAN	67	8.56	127	8.70	28.58
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	75	10.36	139	10.40	33.87
WEIGHTED AVG.		9.69		9.71	32.76
MEDIAN	69	8.40	128	8.52	25.10
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
5 FACILITIES					
UNWEIGHTED AVG.	41	21.77	74	21.90	60.31
WEIGHTED AVG.		20.06		19.96	60.64
MEDIAN	42	22.00	76	22.82	58.00

TABLE F-11

SUMMARY TABLE
RANK ORDER OF OXIDATION DITCH FACILITIES
BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES
TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
31 FACILITIES					
UNWEIGHTED AVG.	95	13.81	155	13.89	29.62
WEIGHTED AVG.		12.27		12.74	24.87
MEDIAN	74	11.28	136	11.65	21.03
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
30 FACILITIES					
UNWEIGHTED AVG.	93	14.02	151	14.11	30.32
WEIGHTED AVG.		12.53		13.04	25.78
MEDIAN	73	12.26	136	12.06	23.51
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	98	13.62	159	13.72	30.43
WEIGHTED AVG.		12.25		12.75	25.42
MEDIAN	80	12.26	136	12.06	23.51
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
10 FACILITIES					
UNWEIGHTED AVG.	76	20.89	141	20.94	55.53
WEIGHTED AVG.		20.75		20.89	47.46
MEDIAN	55	20.05	95	19.75	47.79

TABLE F-12

SUMMARY TABLE
RANK ORDER OF OXIDATION DITCH FACILITIES
BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES
TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
31 FACILITIES					
UNWEIGHTED AVG.	95	13.81	162	13.87	55.05
WEIGHTED AVG.		12.27		12.71	46.40
MEDIAN	74	11.28	144	11.46	39.00
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
30 FACILITIES					
UNWEIGHTED AVG.	93	14.02	158	14.09	56.50
WEIGHTED AVG.		12.53		13.03	48.44
MEDIAN	73	12.26	142	12.14	40.50
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	98	13.62	165	13.69	57.39
WEIGHTED AVG.		12.25		12.72	48.01
MEDIAN	80	12.26	147	12.14	40.50
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
10 FACILITIES					
UNWEIGHTED AVG.	76	20.89	146	20.96	110.59
WEIGHTED AVG.		20.75		20.87	95.53
MEDIAN	55	20.05	101	19.83	105.50

TABLE F-13

SUMMARY TABLE
RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
45 FACILITIES					
UNWEIGHTED AVG.	47	26.69	72	26.89	49.14
WEIGHTED AVG.		27.77		28.10	58.56
MEDIAN	35	24.04	52	24.07	38.50
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
45 FACILITIES					
UNWEIGHTED AVG.	47	26.69	72	26.89	49.14
WEIGHTED AVG.		27.77		28.10	58.56
MEDIAN	35	24.04	52	24.07	38.50
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	47	19.10	69	19.19	34.81
WEIGHTED AVG.		18.64		18.88	33.19
MEDIAN	38	18.96	56	19.14	31.18
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
17 FACILITIES					
UNWEIGHTED AVG.	41	22.01	63	22.33	41.21
WEIGHTED AVG.		21.65		21.96	40.71
MEDIAN	43	23.16	67	23.16	36.00

TABLE F-14

SUMMARY TABLE
RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES BOD5 EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
45 FACILITIES					
UNWEIGHTED AVG.	47	26.69	75	26.78	59.38
WEIGHTED AVG.		27.77		27.70	79.71
MEDIAN	35	24.04	61	23.36	47.00
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
45 FACILITIES					
UNWEIGHTED AVG.	47	26.69	75	26.78	59.38
WEIGHTED AVG.		27.77		27.70	79.71
MEDIAN	35	24.04	61	23.36	47.00
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	47	19.10	74	19.18	44.34
WEIGHTED AVG.		18.64		18.88	53.23
MEDIAN	38	18.96	66	19.31	40.20
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
17 FACILITIES					
UNWEIGHTED AVG.	41	22.01	67	22.17	49.96
WEIGHTED AVG.		21.65		21.89	51.44
MEDIAN	43	23.16	78	22.99	45.67

TABLE F-15

SUMMARY TABLE
RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	71	45.79	90.36
WEIGHTED AVG.		38.18		40.09	77.50
MEDIAN	35	42.32	52	44.00	69.16
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	71	45.79	90.36
WEIGHTED AVG.		38.18		40.09	77.50
MEDIAN	35	42.32	52	44.00	69.16
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	46	33.87	69	35.21	70.67
WEIGHTED AVG.		30.21		31.84	63.76
MEDIAN	38	30.30	56	30.52	61.48
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
26 FACILITIES					
UNWEIGHTED AVG.	38	35.50	58	37.00	74.39
WEIGHTED AVG.		35.66		37.12	76.23
MEDIAN	38	32.16	56	33.48	61.88

TABLE F-15

SUMMARY TABLE
RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 95TH PERCENTILE OF 30-DAY MOVING AVERAGES TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 30-DAY MOVING AVGS	MEAN OF 30-DAY AVGS	95TH %ILE 30-DAY AVGS
TOTAL SAMPLE					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	71	45.79	90.36
WEIGHTED AVG.		38.18		40.09	77.50
MEDIAN	35	42.32	52	44.00	69.16
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	71	45.79	90.36
WEIGHTED AVG.		38.18		40.09	77.50
MEDIAN	35	42.32	52	44.00	69.16
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	46	33.87	69	35.21	70.67
WEIGHTED AVG.		30.21		31.84	63.76
MEDIAN	38	30.30	56	30.52	61.48
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES <=30 MG/L					
26 FACILITIES					
UNWEIGHTED AVG.	38	35.50	58	37.00	74.39
WEIGHTED AVG.		35.66		37.12	76.23
MEDIAN	38	32.16	56	33.48	61.88

TABLE F-16

SUMMARY TABLE
RANK ORDER OF WASTE STABILIZATION POND FACILITIES BASED ON 99TH PERCENTILE OF 7-DAY MOVING AVERAGES
TSS EFFLUENT VALUES

	# OF DAILY OBS.	DAILY MEAN	# OF 7-DAY MOVING AVGS	MEAN OF 7-DAY AVGS	99TH %ILE 7-DAY AVGS
TOTAL SAMPLE					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	74	45.34	121.93
WEIGHTED AVG.		38.18		39.59	114.97
MEDIAN	35	42.32	61	42.84	92.00
SAMPLE EXCLUDING FACILITIES W/ ADDITIONAL PROCESSES					
45 FACILITIES					
UNWEIGHTED AVG.	46	44.46	74	45.34	121.93
WEIGHTED AVG.		38.18		39.59	114.97
MEDIAN	35	42.32	61	42.84	92.00
SAMPLE EXCLUDING OUTLIER FACILITIES AND FACILITIES W/ ADDITIONAL PROCESSES					
28 FACILITIES					
UNWEIGHTED AVG.	46	33.87	73	34.73	90.45
WEIGHTED AVG.		30.21		31.30	86.09
MEDIAN	38	30.30	66	31.02	84.50
SAMPLE EXCLUDING OUTLIER AND ADDITIONAL PROCESS FACILITIES AND FACILITIES W/ 95TH %ILES (30-DAY AVG.) <=30 MG/L					
26 FACILITIES					
UNWEIGHTED AVG.	38	35.50	62	36.48	95.51
WEIGHTED AVG.		35.66		36.25	102.88
MEDIAN	38	32.16	66	33.37	86.50

Table F-17
Trickling Filter BOD Log-Transform

Fac #	N	Log Mean	Exp. Val	Std Dev Log Mean (30)	95th %ile
655	268	3.355	29.01	0.72	30.20
970	164	3.212	26.23	2.65	30.60
216	104	3.286	27.66	1.83	30.67
603	112	3.011	22.95	4.87	30.96
306	131	3.188	25.89	3.12	31.02
524	519	3.315	28.50	1.95	31.71
255	49	2.795	20.32	7.43	32.59
604	260	3.332	29.10	2.28	32.85
345	326	3.370	30.01	1.99	33.28
956	105	2.998	23.82	7.78	36.61
244	26	3.118	25.79	6.68	36.77
553	110	3.335	30.09	4.49	37.48
952	207	3.486	33.73	2.51	37.87
325	235	3.084	25.92	9.09	40.88
653	282	3.685	40.07	0.57	41.01
222	72	3.276	29.72	7.66	42.33
651	628	3.377	31.91	6.39	42.42
54	499	3.238	29.13	8.67	43.39
51	502	3.397	32.56	5.06	43.51
551	24	3.515	35.64	5.24	44.27
954	293	3.250	29.52	8.97	44.27
953	96	3.586	37.66	4.23	44.63
412	221	3.446	34.10	7.00	45.62
249	114	3.458	34.43	6.96	45.88
307	297	3.505	35.66	6.28	45.99
305	310	3.629	39.47	5.03	47.83
171	57	3.457	35.02	8.94	49.72
956	201	3.404	33.75	9.79	49.86
202	204	3.173	29.02	13.02	50.45
254	41	3.308	32.06	12.90	53.28
950	99	3.394	35.56	17.97	65.11
906	315	3.442	36.75	17.27	65.16
413	285	3.829	49.30	11.93	68.93
550	24	2.731	24.15	28.70	71.36
56	724	3.834	50.80	17.71	79.94
656	274	3.922	54.56	16.70	82.03
951	56	3.404	38.33	30.47	88.46
311	262	3.915	58.23	39.38	123.01

Summary: 38 Facilities

Average	224	33.33	9.32	48.74
Weighted average		35.33	8.88	50.10
Median	206	31.99	6.98	43.89

Excluding Facility #550: (37 Facilities remaining)

Average	229	33.58	8.80	48.13
Weighted average		35.36	8.84	50.04
Median	207	32.06	6.96	43.51

Table F-18
Trickling Filter TSS Log-Transform

Fac #	N	Log Mean	Exp. Val	Std Dev Log Mean (30)	95th %ile
252	312	3.353	29.15	1.12	30.99
345	326	3.330	28.94	2.04	32.30
553	117	2.804	20.46	7.48	32.77
52	503	3.268	27.92	3.38	33.48
651	635	3.201	27.01	5.15	35.48
220	23	3.227	27.59	5.05	35.89
249	105	3.309	29.36	4.34	36.49
244	27	2.898	22.60	9.41	38.08
954	13	3.238	28.37	6.44	38.96
465	24	2.730	20.67	11.67	39.87
255	49	2.655	19.91	12.65	40.72
653	481	3.693	40.37	0.321	41.25
551	24	3.185	27.83	8.42	41.68
906	315	3.164	27.53	8.92	42.21
56	727	3.260	29.39	7.87	42.33
412	83	3.229	29.26	9.12	44.06
524	519	3.134	27.29	10.22	44.10
650	182	3.082	26.67	11.81	46.09
53	23	3.432	33.93	7.77	46.72
311	262	3.454	34.54	7.70	47.20
656	276	3.245	30.03	11.14	48.35
171	75	3.345	32.15	9.87	48.38
307	297	3.479	35.42	8.08	48.71
222	37	3.504	36.54	9.25	51.76
603	114	2.951	25.48	16.74	53.01
550	23	2.292	17.74	23.27	56.01
202	187	3.363	33.91	14.56	57.86
254	43	3.032	29.04	27.01	73.47
54	106	3.160	31.97	28.63	79.07
950	18	3.413	37.61	25.24	79.13
418	303	3.201	32.94	28.89	80.46
51	52	3.057	32.08	43.71	103.99
963	348	2.606	26.76	69.31	140.77

Summary: 33 Facilities

Average	201	29.10	13.84	51.87
Weighted average		29.90	12.00	49.64
Median	114	29.04	9.41	44.10

Excluding Facility #51, 550, 963: (30 Facilities remaining)

Average	207	29.46	10.68	47.03
Weighted average		30.10	8.48	44.05
Median	114	29.10	9.19	43.20

Table F-19
BOD WSP Log-Transform

Fac #	N	Log Mean	Exp. Val	Std Dev Log Mean (30)	95th %ile
654	46	3.112	24.42	3.60	30.35
133	51	2.959	22.14	5.22	30.73
167	28	2.969	22.75	6.29	33.10
59	23	3.088	24.59	5.17	33.10
106	45	3.056	24.09	5.56	33.25
123	40	2.298	15.39	10.96	33.42
169	81	2.603	18.53	10.08	35.12
168	35	2.896	22.09	7.95	35.17
112	63	3.059	25.28	8.69	39.57
132	43	3.162	27.14	7.84	40.04
124	44	2.952	23.83	10.43	41.00
122	34	3.250	30.00	10.63	47.49
660	44	3.084	27.18	13.48	49.35
402	50	2.597	21.14	22.07	57.45
337	104	3.624	40.98	10.95	58.99
664	37	3.672	43.74	15.09	68.57
658	48	4.043	72.49	108.00	250.09

Summary: 17 facilities

Average	48	28.57	15.41	53.93
Weighted average		29.25	15.68	55.07
Median	44	24.42	10.08	39.57

Excluding: 658 (16 facilities remaining)

Average	48	25.83	9.62	41.67
Weighted average		26.55	9.91	42.88
Median	44	24.26	9.39	37.37

Table F-20
WSP TSS Log-Transform

Fac #	N	Log Mean	Exp. Val	Std Dev Log Mean (30)	95th %ile
111	36	2.862	21.75	8.60	35.89
137	47	2.872	22.26	9.72	38.26
153	27	2.853	23.91	17.15	52.12
134	35	3.337	32.95	13.47	55.11
165	53	3.168	29.51	15.70	55.34
166	20	2.937	25.90	19.85	58.55
176	20	2.618	21.57	22.91	59.26
654	46	3.655	42.94	14.29	66.45
156	71	3.231	32.83	24.58	73.27
168	35	2.917	27.28	29.21	75.33
106	45	3.476	39.16	23.88	78.44
122	34	3.092	31.32	33.41	86.27
337	104	4.033	60.31	17.17	88.55
136	31	3.506	41.60	32.27	94.69
131	18	3.540	42.59	31.86	95.00
167	28	4.084	63.87	21.33	98.95
59	18	3.352	40.12	52.14	125.89
112	64	3.558	46.07	51.17	130.24
132	43	3.659	49.70	52.56	136.16
124	44	2.833	30.87	73.03	151.01
123	40	2.754	29.61	74.63	152.38
402	52	2.789	30.62	79.55	161.48
659	40	3.645	52.16	77.57	179.77
169	81	3.276	42.91	99.94	207.31
133	51	3.606	56.46	143.50	292.57
660	44	4.032	84.29	292.70	565.80
664	36	4.400	111.40	359.70	703.00
658	48	3.945	89.71	540.60	978.98

Summary: 28 facilities

Average	43	3.358	43.70	79.23	174.85
Weighted average		3.405	45.21	82.65	181.19
Median	44	3.407	39.64	32.07	94.85

Excluding Facilities #59, 112, 122-124, 132-133, 168-169, 176, 402, 658-660, 664: (13 facilities remaining)

Average	43	3.350	36.89	19.22	68.51
Weighted average		3.419	34.68	18.49	69.42
Median	44	3.337	32.95	17.17	66.45

Table F-21
SUMMARY TABLE
RELATIONSHIP OF 30-DAY (95TH %ILE) VALUES TO 7-DAY (99TH %ILE) VALUES

Sample Used	Ratios of 7-day : 30-day based on:		
	Unweighted Average	Weighted Average	Median
Trickling Filter, Rock Media, BOD_5			
1	1.39	1.38	1.43
2	1.40	1.39	1.36
3	1.42	1.42	1.41
4	1.45	1.43	1.43
Average of (4) for BOD_5: 1.44			
Trickling Filter, Rock Media, SS			
1	1.58	1.59	1.39
2	1.59	1.58	1.38
3	1.64	1.64	1.33
4	1.68	1.67	1.46
Average of (4) for SS: 1.60			
Average of (4) for BOD_5 and SS: 1.52			
Trickling Filter, Plastic Media, BOD_5			
1	1.64	1.48	1.26
2	1.76	1.62	1.33
3	1.53	1.53	1.19
4	1.68	1.68	1.32
Average of (4) for BOD_5: 1.56			
Trickling Filter, Plastic Media, SS			
1	1.46	1.46	1.86
2	1.42	1.41	1.65
3	1.52	1.54	1.55
4	1.43	1.40	1.39
Average of (4) for SS: 1.41			
Average of (4) BOD_5 and SS: 1.48			

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1 = Total Sample
2 = Total Sample, excluding facilities using additional processes
3 = Total Sample, excluding outliers and additional processes
4 = Sample of facilities eligible under proposed rule.

TABLE F-21 (continued)

Sample Used	Ratios of 7-day : 30-day based on: Unweighted Average	Weighted Average	Median
Waste Stabilization Ponds, BOD_5			
1	1.20	1.36	1.22
2	1.21	1.36	1.22
3	1.27	1.60	1.29
4	1.21	1.26	1.27

Average of (4) for BOD_5: 1.25

Sample Used	Ratios of 7-day : 30-day based on: Unweighted Average	Weighted Average	Median
Waste Stabilization Ponds, SS			
1	1.35	1.48	1.33
2	1.35	1.48	1.33
3	1.28	1.35	1.39
4	1.28	1.35	1.40

Average of (4) for SS: 1.34

Average of (4) BOD_5 and SS: 1.30

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1 = Total Sample
2 = Total Sample, excluding facilities using additional processes
3 = Total Sample, excluding outliers and additional processes
4 = Sample of facilities eligible under proposed rule.

Technical Support Document for Secondary Treatment (CBOD$_5$)

Introduction

This report summarizes the statistical analyses used to derive a CBOD$_5$ effluent limitation that would be equivalent to the existing 30 mg/L BOD$_5$ requirement for secondary treatment facilities.

The analysis describes the rationale for screening BOD$_5$ and CBOD$_5$ data submitted to the Agency and the types of statistical methodologies used to process the data. The report confirms that measurements of CBOD$_5$ and BOD$_5$ effluent values for secondary treatment are not equivalent. The report suggests that a 30-day average CBOD$_5$ value of 25 mg/L is comparable to a 30-day average BOD$_5$ value of 30 mg/L.

Background

In 1973, the Environmental Protection Agency (EPA) required all secondary treatment facilities to achieve 30 mg/L BOD$_5$ on a 30-day average basis. There are two primary sources of oxygen demanding materials in municipal wastewaters: carbonaceous and nitrogenous. The BOD$_5$ test is expected to measure primarily the oxygen demand that may be exerted from carbonaceous (organic) materials in the wastewater and is not expected to measure the nitrogenous demand which usually is exerted after 5 days incubation. However, when substantial nitrifying bacteria are present in the BOD$_5$ test, significant nitrogenous oxygen demand (NOD) may be exerted and the BOD$_5$ parameter may not provide a good measure of plant efficiency and effluent quality.

Significant nitrifying bacteria are more likely to be present in underloaded or overdesigned secondary facilities that are providing for better than secondary treatment. The additional oxygen demand exerted by the nitrifying bacteria can erroneously lead one to believe that effluent quality and plant performance have decreased, when in actuality plant effluent quality and treatment efficiency have remained constant or improved. To correct this problem, EPA has proposed an alternative oxygen demand test procedure, the carbonaceous BOD$_5$ (CBOD$_5$) test.

The CBOD$_5$ test prevents the oxidation of nitrogenous material through use of an "inhibitor" that blocks the conversion of ammonia to nitrite by Nitrosomonas bacteria. Thus, the inhibited test insures that only the organic (carbonaceous) material will exert an oxygen demand. For this reason, CBOD$_5$ is a more reliable parameter to determine treatment efficiency and effluent quality. Where NOD is important to preserve water quality, measurement of ammonia is the most appropriate test procedure.

Although the BOD$_5$ test is intended to measure primarily the carbonaceous oxygen demand of the effluent, a small population of nitrifying bacteria are typically present in wastewater effluents even under cold weather conditions in properly designed secondary facilities. These populations may exert a small NOD in the test; thus, CBOD$_5$ and BOD$_5$ results are not necessarily equivalent, and the secondary standard 30 mg/L BOD_5 may require adjustment when the oxygen demand parameter $CBOD_5$ is used. Since it is not the intention of the Agency to relax current secondary treatment requirements with the introduction of the $CBOD_5$ parameter in lieu of BOD_5, an evaluation of the magnitude of difference between the two test results has been conducted.

Methodology/Screening Criteria

To ensure that a comparable level of effluent quality is required for secondary treatment facilities under either BOD_5 or $CBOD_5$ pollutant parameters, the Agency has analyzed parallel BOD_5 and $CBOD_5$ data from secondary treatment facilities achieving the existing 30 mg/L requirement for BOD_5 to determine the corresponding $CBOD_5$ effluent concentrations.

Screening criteria were developed based on the 1973 methodology used to establish the existing 30 mg/L BOD_5 standard. The criteria also reflect design practice concerning the critical design period for a secondary facility.

The original study of secondary treatment plants conducted by EPA in 1973 included only facilities that were "well operated" and "operated at or near design flow." These criteria eliminated facilities that were significantly underloaded or overdesigned. Our study similarly eliminates these facilities since data from underloaded/overdesigned facilities would exhibit greater differences between BOD_5 and $CBOD_5$ than would be exhibited at design conditions. The reasons for these differences are given later.

To insure that the BOD_5 limitation does not result in more or less stringent requirements than the current 30 mg/L BOD_5 limitation, it is necessary to evaluate the effluent data from the critical time period that controls plant design. Since the 30 mg/L BOD_5 requirement is a year round requirement, a facility must be designed to achieve 30 mg/L BOD_5 under the most critical annual condition. The critical design period for most secondary facilities is the winter when biological activity is lowest. Thus, the data set should include only winter operating effluent quality.

This requirement eliminates most summer operations data which tend to exhibit a greater difference between $CBOD_5$ and BOD_5 due to increased nitrifier growth rates in warmer temperatures. If this data were not eliminated, the degree of NOD exerted under design conditions (winter) would be overstated and $CBOD_5$ limits would be more restrictive than the 30 mg/L BOD_5 limits, (i.e., treatment more stringent than secondary would be required).

Nitrifying bacteria populations are significantly influenced by the mean cell residence time (MCRT) of the facility which is a function of detention time and loading. Since hydraulically or organically underloaded facilities, as well as overdesigned plants, have longer detention times than fully loaded facilities, they will tend to have a longer MCRT and thus increase a potential for supporting significant nitrifying populations. Hydraulically underloaded facilities were detected by comparing design flow with actual flow. Data from those facilities operating at less than about 75% design flow were discarded.

Overdesigned and organically underloaded plants are detected by significant NOD in the BOD_5 test. During cold weather periods, nitrifying bacteria growth rates are drastically reduced and only small amounts of such bacteria should be present in a typically designed secondary facility (MCRT ranging 4-7 days). Since only small quantities of nitrifiers should be present in the winter if the plant is properly designed, substantial NOD exertion (over 10-15 mg/L) in the BOD_5 test would be evidence of overdesign or significant organic underloading. These facilities should not be included since they are not "at or near design conditions" or not properly designed.

For the reasons given above, the sampled facilities and data points were selected according to the following criteria:

- facility is classified as secondary treatment facility
- facility discharge approximates design flow
- facility provides parallel BOD_5/$CBOD_5$ cold weather month performance data.

Analyses of Effluent Data

The objective of the analyses was to identify an average amount of the nitrogenous demand exerted in the BOD_5 test under design conditions, which could then be used to adjust effluent limitations for secondary treatment facilities based on BOD_5.

Table 1 contains the screened data used in the statistical analysis. Twenty-six facilities are included in the sample with 82 months of parallel $CBOD_5$ and BOD_5 test samples. The data are primarily winter effluent data (i.e., sampled December through March) except for data from 7 facilities in EPA Region IV (deep South) which were sampled in August. The Region IV data were included in the analyses since little nitrification was occurring in the test sample.

The majority of the data present were 30-day average values. The data show that the difference between monthly BOD_5 and $CBOD_5$ ranged from -4 (Medina, MN - March) to 25 mg/L (Hastings, MN - February) with an average of about 4 mg/L. It should be noted that the facilities with several high NOD measurements up to 25 mg/L such as Hastings, MN also had several months with a more typical NOD ranging 1 to 2 mg/L. $CBOD_5$ remained fairly constant although BOD_5 fluctuated widely.

Analytical Procedures

Two types of statistical analyses were performed with the data. In the first analysis, average effluent data from each facility were lumped and fit with a log normal probability distribution.

These analyses are presented for BOD_5, $CBOD_5$ and NOD in Figures 1, 2 and 3, respectively.

Figure 3 indicates that the median NOD exerted in wintertime BOD_5 tests is about 4 mg/L; approximately 30% of all facilities exhibited 1 mg/L NOD or less. Although the analyses indicate that the median NOD is about 4 mg/L, the analyses cannot predict the likely NOD when BOD_5 is 30 mg/L. To determine this, linear reqressions were used.

For the linear regression analyses performed on the data, the best fit of the data was expressed in terms of a linear equation in the form of Y=A+bX, where (A) accounts for a constant residual shift of the line upward or downward. An index of a determination (R^2) for the regression provided a measure of closeness of fit. A value of $R^2 = 1.0$ is interpreted as a perfect fit, whereas a value of $R^2 = 0$ shows that there is no fit.

Several different regression analyses (Figures 4, 5 and 6) of the data set yielded an R^2 value ranging from .89 to .93 for a linear function fit with 82 monthly average data points. The excellent fit was expected since BOD_5 is primarily measuring $CBOD_5$ during the design condition.

The different regressions test the sensitivity of the regression to the deletion of several data points. Both the Hastings and Metro data exhibited unusually high NOD (Hastings up to 25 mg/L and Metro up to 21 mg/L). The regressions were run with all Hastings and Metro data excluded (Figure 4), only Hastings excluded (Figure 5), and only the NOD values above 15 mg/L excluded (Figure 6).

The regressions show that exclusion of the data has little impact on results with all regressions indicating about a 26 mg/L $CBOD_5$ when BOD_5 is 30 mg/L. The 95% confidence interval for $CBOD_5$ at $BOD_5 = 30$ mg/L, ranges about 24 to 27 mg/L.

Conclusions

Based on the above, $CBOD_5$ test results are not equivalent to BOD_5 test results for most plants at design conditions. Based on the statistical analyses, the average amount of NOD exerted during winter months for properly designed facilities near design flow is about 4 mg/L. Regression analyses indicate that when BOD_5 is 30 mg/L, $CBOD_5$ ranges 24 to 27 mg/L. It appears that an effluent requirement of 25 mg/L $CBOD_5$ is approximately equal to the present 30 mg/L BOD_5 requirement. For approximately 30 percent of all facilities this will represent a slightly more stringent requirement than the present 30 mg/L BOD_5; however, the difference is insignificant and within the variation of the test procedure itself.

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Table 1

Winter Comparison of $CBOD_5$ and $TBOD_5$ for Secondary Treatment Facilities

Plant	Year	Month	Inf. Temp. °C	$TBOD_5$ mg/l	$CBOD_5$ (mg/l)	NOD (mg/l)	TSS (mg/l)
Minn.							
*Anoka	81	Dec.	16	20	17	3	12
	82	Jan.	14	18	13	5	8
	82	Feb.	14	14	12	2	6
	AVG		15	17	14	3	9
*Bayport	81	Nov.	19	12	8	4	8
	81	Dec.	17	13	8	5	8
	82	Jan.	18	17	12	5	8
	82	Feb.	18	14	11	3	13
	82	Mar.	17	9	9	0	9
	82	April	17	10	9	1	10
	AVG		18	13	10	3	9
*Chaska	81	Nov.	15	18	15	3	11
	81	Dec	13	20	17	3	13
	82	Jan.	11	21	15	6	13
	82	Feb.	10	25	19	6	16
	82	Mar.	9	18	14	4	11
	82	April	10	14	14	0	7
	AVG		11	19	16	4	12
*Cottage Grove	81	Nov.	17	12	9	3	5
	81	Dec.	14	20	12	8	7
	82	Jan.	11	22	18	4	9
	82	Feb.	11	17	13	4	10
	82	Mar.	11	11	11	0	9
	82	April	11	13	12	1	10
	AVG		13	16	13	3	9
*Hastings	81	Nov.	17	30	20	10	22
	81	Dec	16	47	30	17	28
	82	Jan.	13	42	31	11	36
	82	Feb.	12	56	31	25	39
	82	Mar.	12	36	34	2	50
	82	April	12	25	24	1	36
	AVG		14	39	28	11	35
*Maple Plain	81	Nov.	15	10	9	1	19
	81	Dec	13	26	27	-1	11
	82	Jan.	12	29	28	1	8
	82	Feb.	11	9	9	0	2
	82	Mar.	11	18	18	0	10
	82	April	12	28	27	1	8
	AVG		12	20	20	.3	10

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Table 1 (cont.)

Plant	Year	Month	Inf. Temp. °C	TBOD$_5$ mg/l	CBOD$_5$ (mg/l)	NOD (mg/l)	#SAMP	TSS (mg/l)
Rockford Ill.	80	Jan.		30	24	6	11	
	80	Feb.		30	29	1	8	8
	AVG			30	27	4		
Murrysville, PA Franklin TWSP/WWTP	82	June	17	38	34	4	14	26
Region IV	81	Aug.						
TF B				23	19	4		8
TF C				27	24	3		9
O.D.AS. D				5	4	1		11
Lagoon E				31	27	4		33
Lagoon F				39	41	-2		170
AS H				14	14	0		28
Delaware River Basin	80	Nov.		25	20	5	13	
	80	Dec		57	45	12	31	
	81	Jan.		43	38	5	30	
	81	Mar.		27	23	4	17	
	AVG			38	32	7		
Kearney, NEB	82	Mar.		28	24	4	22	21
Seward, NEB	82	Feb.		10	5	5	41	
Grants Pass Oregon	80	Nov.		7	6	1	9	9
	80	Dec		8	7	1	9	9
	81	Jan.		8	8	0	10	10
	81	Feb.		19	18	1	10	45
	81	Mar.		11	9	2	7	11
	AVG			11	10	1	17	
	80	Jan.		9	8	1	10	9
	80	Feb.		7	7	0	8	8
				8	8	1		9
Cold Springs (TF)	79	Dec.		10	10	0		
	79	Jan.		36	29	7		
	79	Feb.		11	7	4		
	79	Mar.		15	9	6		
	AVG			18	14	4		
Kalamazoo, MI	82	Feb.		33	30	3		
	82	Mar.		53	44	9		
	AVG			43	37	6		

TS-6

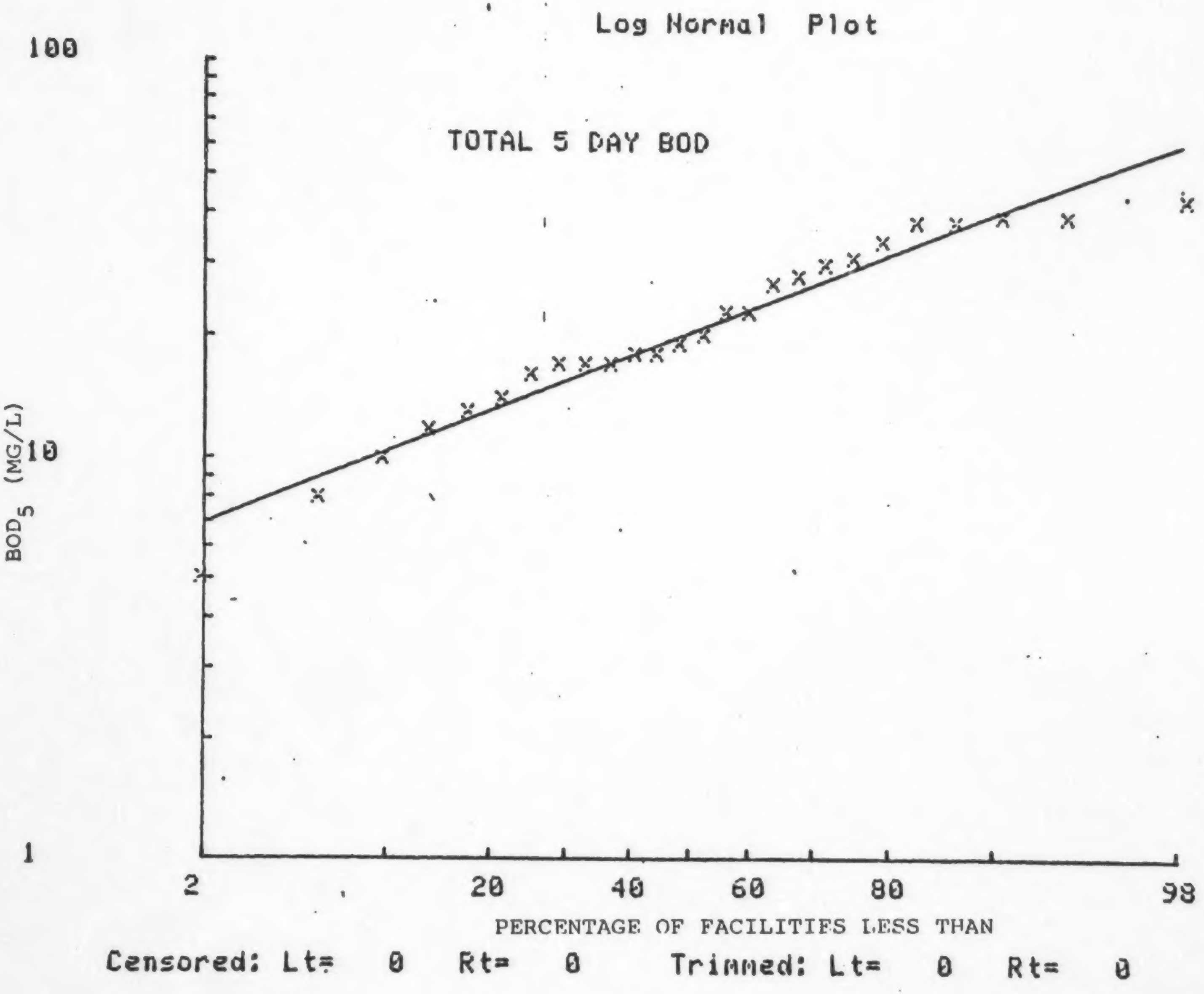
Table 1 (cont.)

Plant	Year	Month	Inf. Temp. °C	TBOD$_5$ mg/l	CBOD$_5$ (mg/l)	NOD (mg/l)	#SAMP	TSS (mg/l)
*Medina	81	Dec	13	16	14	2		10
	82	Jan.	12	19	16	3		19
	82	Mar.	12	12	16	-4		11
	82	April	12	20	19	1		19
	AVG		12	17	16	1		15
*Rosemont	82	Jan.	12	18	18	0		3
*Seneca	81	Nov.	18	23	23	0		18
	81	Dec	16	30	26	4		23
	82	Jan.	14	19	18	1		19
	82	Feb.	13	16	16	0		17
	82	Mar.	13	22	21	1		18
	82	April	13	25	25	0		21
	AVG		15	23	22	1		19
Milwaukee, WI	79	Jan.		14	9	5	9	
Jones Island	79	Feb.		16	12	4	9	
Westside	79	Mar.		20	18	2	9	
	AVG			17	13	4		
Metro WWTP	79	Dec		18	13	5	4	
	80	Jan.		42	21	21	4	
	80	Feb.		36	19	17	9	
	82	Mar.		41	36	5	5	
	AVG			34	22	12		
Pittsfield MA	81	Jan.		16.2	7.4	8.8		
	81	Mar.		7.4	5.0	2.4		
	AVG			11.8	6.2	5.6		

* 30 samples/month

Figure 1

Analysis of BOD_5 Data by Plant



TS-8

Figure 1 (cont.)

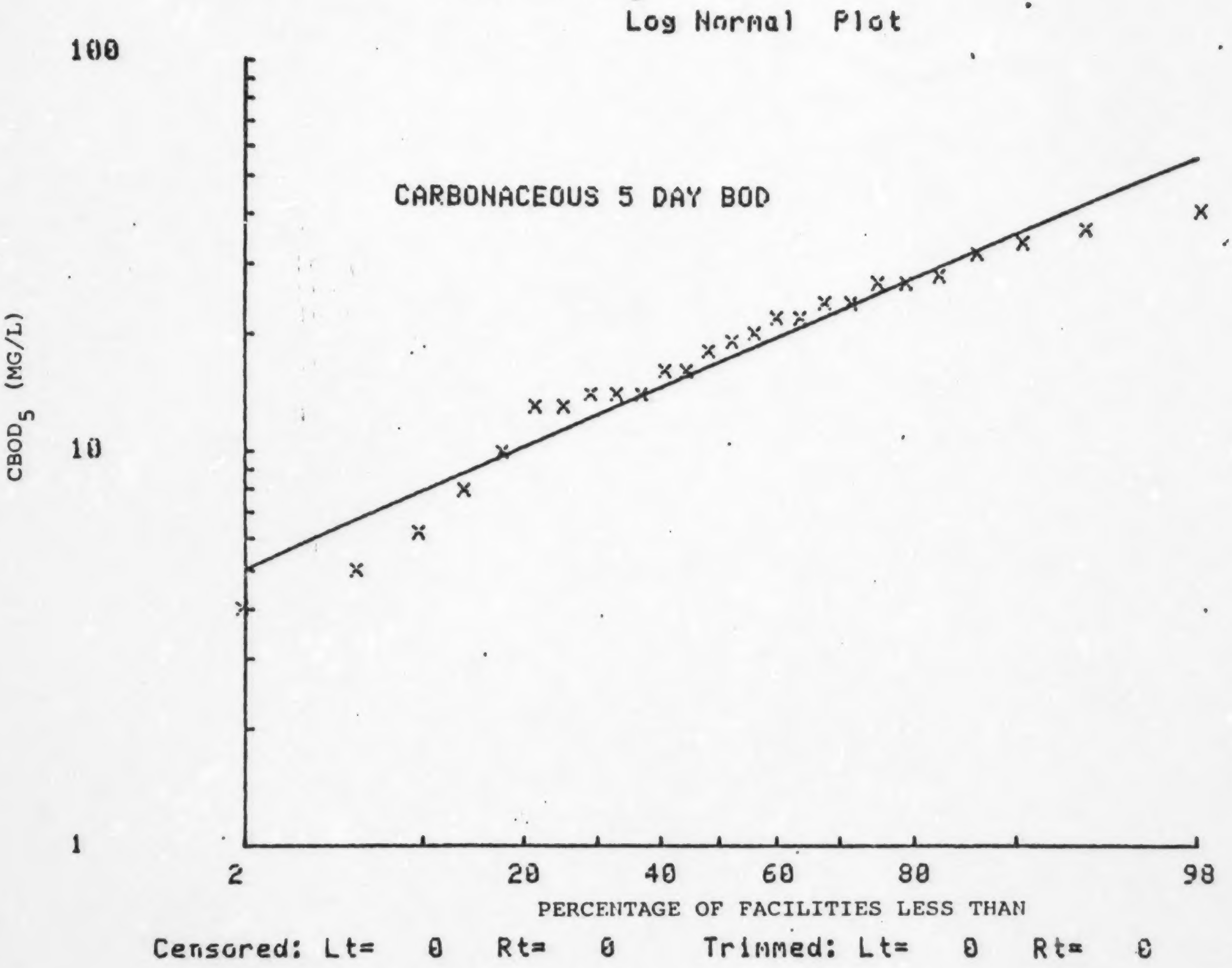
```
                    Simple Statistics
          N                    =26.
          Total                =596.8
          Mean                 =22.9538461538
          Median               =19.5
          Variance             =115.735384615
          Std Dev              =10.7580381397
          Min                  =5.
          Max                  =43.
          Range                =38.
          Skewness             =0.322635462679
          Kurtosis             =1.9890718897
          3rd Moment           =378.757578516
          4th Moment           =24632.9326662
          Coeff of Var         =0.468681286247

Censored: Lt=   0   Rt=   0     Trimmed: Lt=   0   Rt=   0
```

TOTAL 5 DAY BOD

TS-9

Figure 2

Analysis of $CBOD_5$ Data by Plant



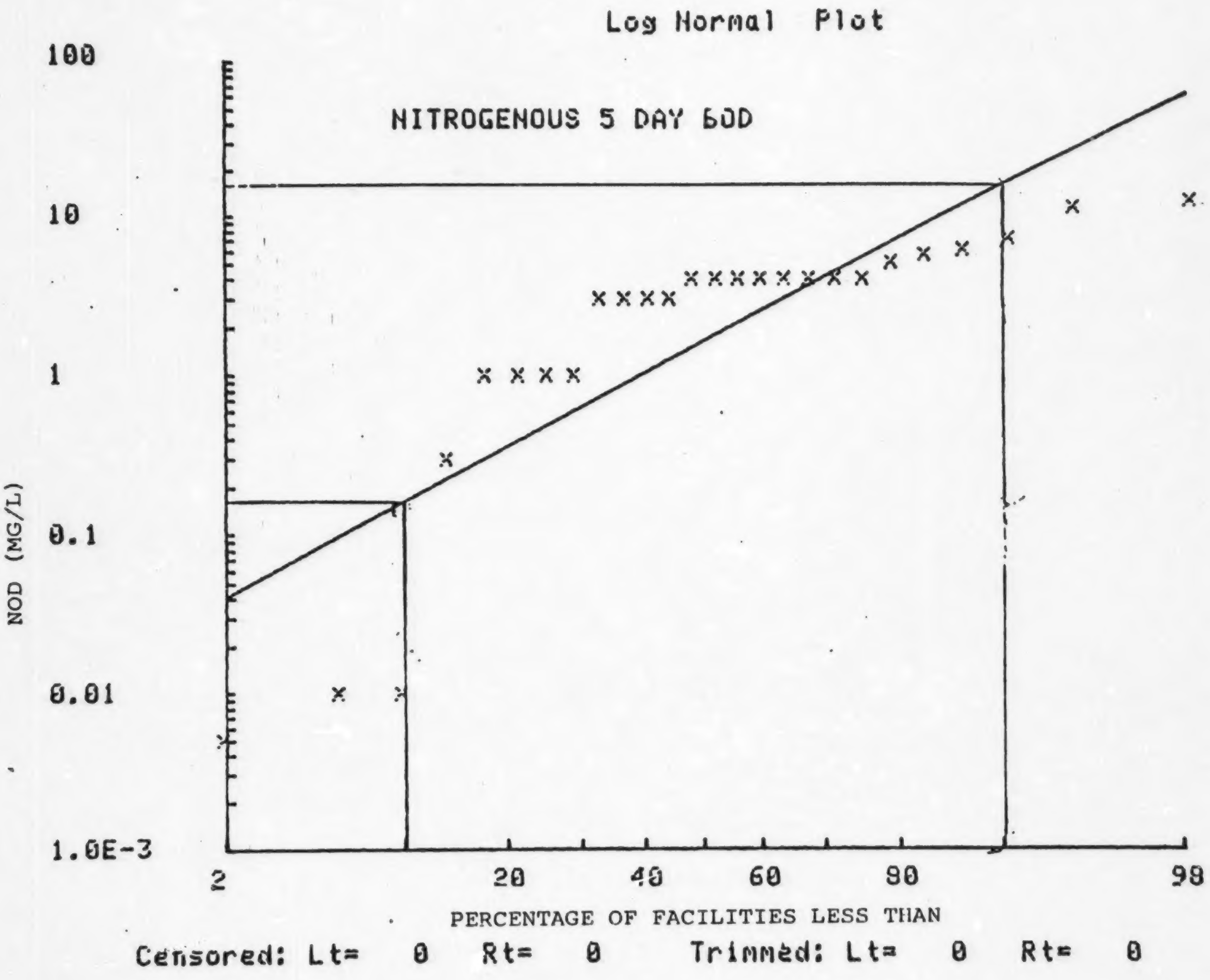
75-10

Figure 2 (cont.)

```
                Simple Statistics
N                       =26.
Total                   =508.2
Mean                    =19.5461538462
Median                  =18.5
Variance                =97.0033846154
Std Dev                 =9.84902962811
Min                     =4.
Max                     =41.
Range                   =37.
Skewness                =0.384024636683
Kurtosis                =2.44175344715
3rd Moment              =345.930942194
4th Moment              =21242.6604152
Coeff of Var            =0.503885813323

Censored: Lt=    0   Rt=    0     Trimmed: Lt=    0   Rt=    0


          CARBONACEOUS 5 DAY BOD
```

Figure 3

Analysis of NOD Data by Plant



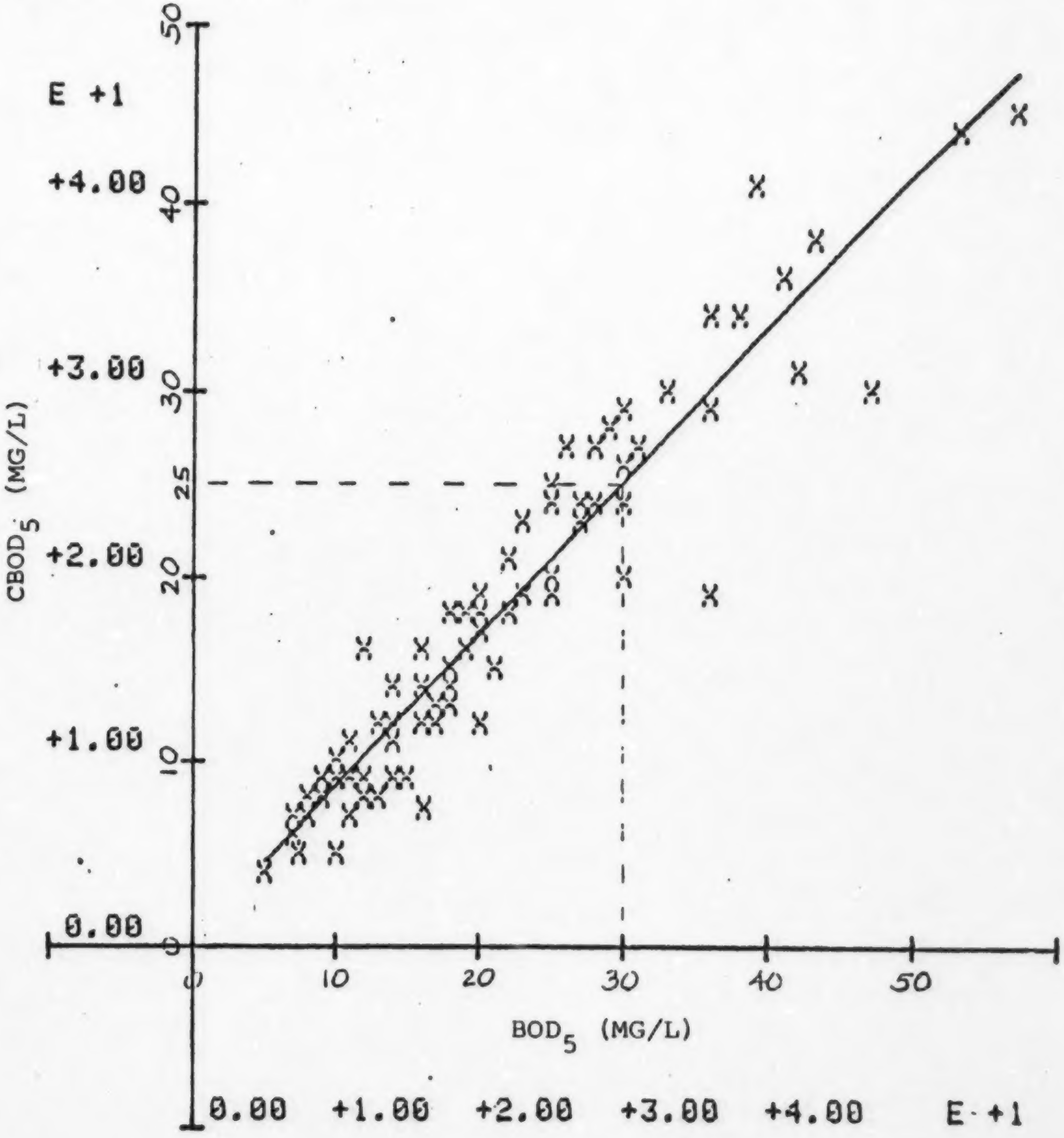
75-12

Figure 3 (cont.)

```
                    Simple Statistics

       N                     =26.
       Total                 =94.925
       Mean                  =3.65096153846
       Median                =4.
       Variance              =9.11530803846
       Std Dev               =3.01915684231
       Min                   =0.005
       Max                   =12.
       Range                 =11.995
       Skewness              =1.15817396249
       Kurtosis              =4.40715662622
       3rd Moment            =30.0525143041
       4th Moment            =338.559111108
       Coeff of Var          =0.826948410851


   Censored: Lt=   0   Rt=   0     Trimmed: Lt=   0   Rt=   0


                    NITROGENOUS 5 DAY BOD
```

Analysis of Monthly Data Without
Hastings and Metro

```
Y = A + B*X

A =
 0.552940905042

B =
 0.818587212009

R-SQUARE =
 0.900072314604

RES ERROR
 9.41432276696

MAX(ABS(RESIDUAL))
 11.0220805374
```

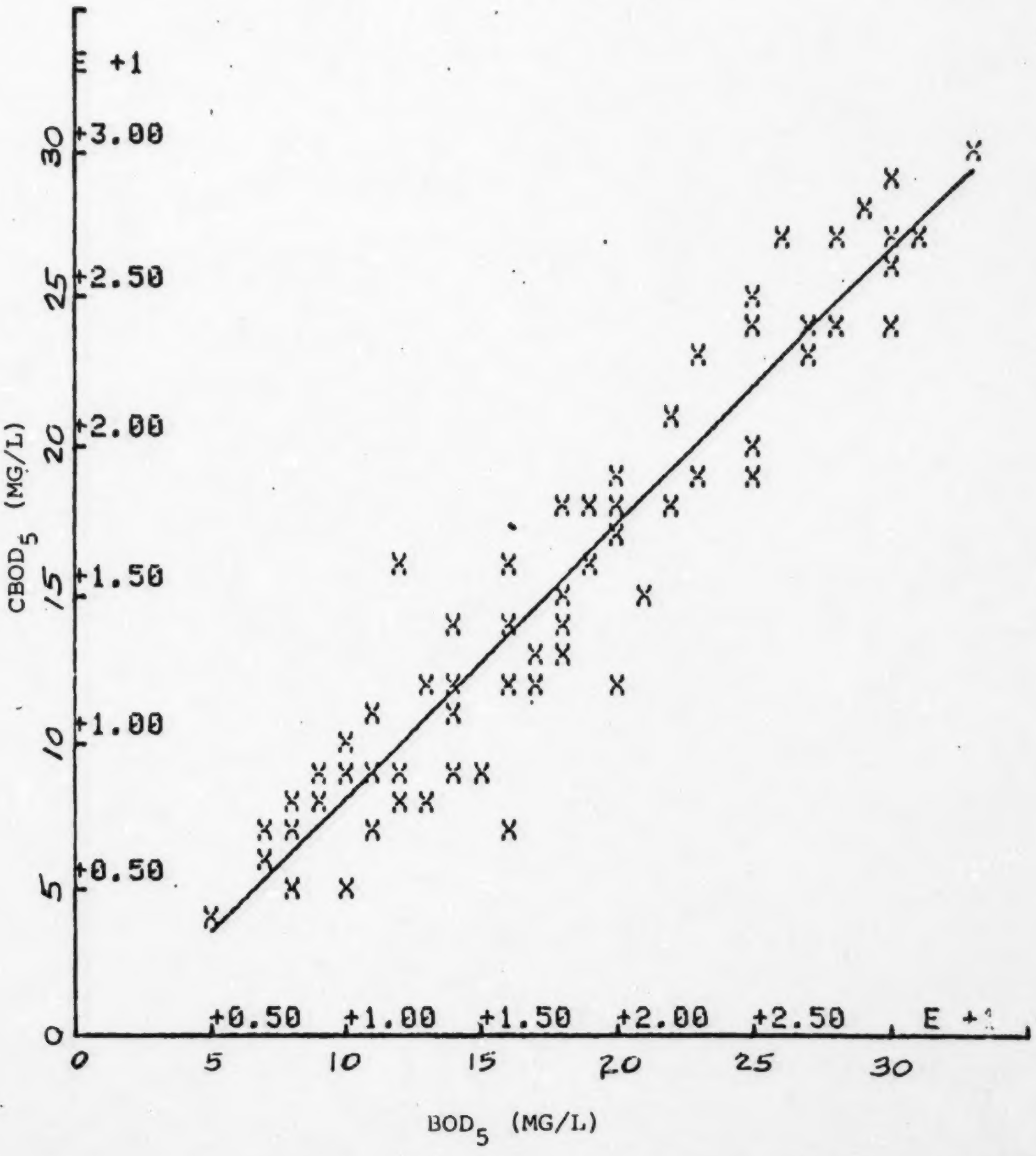


TS-14

Figure 5

Analysis of Monthly Data Near or
Below 30 mg/l (Hastings Omitted)

```
Y = A + B*X

A =
 -1.05698964639

B =
 0.920754572098

R-SQUARE =
 0.895431010632

RES ERROR
 5.17110894191

MAX(ABS(RESIDUAL))
 6.67508350717
```

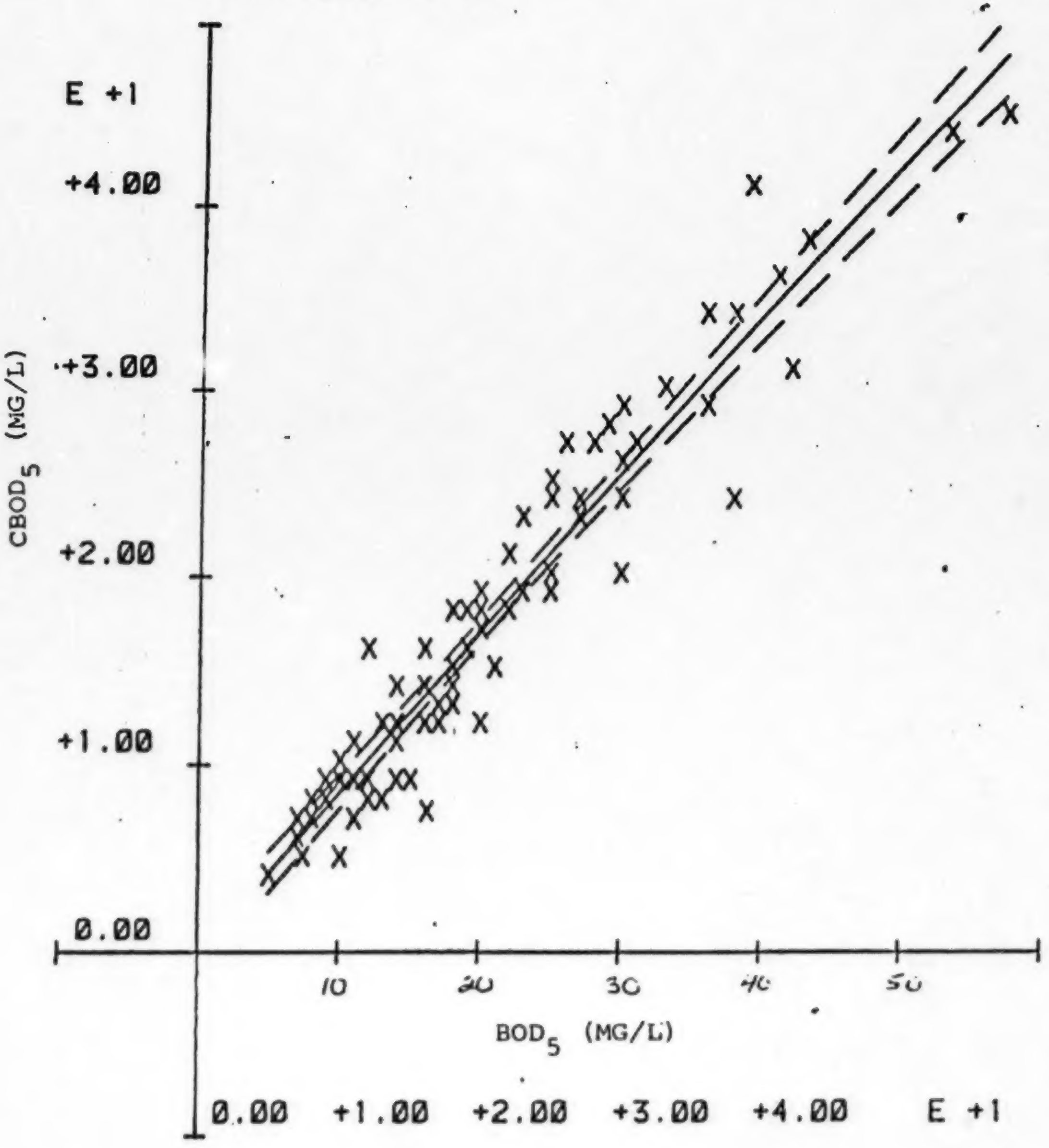


TS-15

Figure 6

Analysis of Monthly Data With
NOD Below 15 mg/1

```
Y = A + B*X

A =
 0.0922890187773

B =
 0.848030446351

R-SOUARE =
 0.919701220983

RES ERROR
 7.60825522318

MAX(ABS(RESIDUAL))
 8.31744598012
```



TS-16